RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part I.] 1925. **[March.**

GENERAL REPORT FOR 1924. BY E. H. PASCOE, M.A., SC.D. (Cantab.), D.SC. (Lond.), F.G.S., F.A.S.B., *Director, Geological Survey of India.*

DISPOSITION LIST.

DURING the period under report the officers of the Department were employed as follows :--

Superintendents.

DR. L. L. FERMOR	Returned from the field on the 28th April 1924. Placed in charge of the Central Provinces and Central India Party. Left for the field on the 4th November 1924.
DR. G. E. PILGRIM	Returned from field work in charge of the North-West Party on the 1st July 1924. Appointed as Palæontologist with effect from the 1st July 1924.

MR. G. H. TIPPER . Returned from combined leave on the 9th November 1924. Placed in charge of office from the 10th November 1924.

DR. G. DE P. COTTER In charge of the Burma Party up to the 24th March 1924. Granted combined leave for two years and four months with effect from the 25th March 1924.

DR. J. COGGIN BROWN Placed in charge of office up to the 14th March 1924; acted as Palæontologist up to the 21st March 1924. Granted combined leave for one year and seven months with effect from the 22nd March 1924.

MR. H. CECIL JONES Returned from field work in charge of the Bihar and Orissa Party on the 14th March 1924. Placed in charge of office from the 15th March 1924 to the 9th November 1924. Acted as Palæontologist from the 22nd March 1924 to the 30th June 1924. Left headquarters on the 5th September 1924 to report on the water supply of the Quetta District and returned on the 25th September 1924. Placed in charge of the Bihar and Orissa Party; left for the field on the 1st December 1924.

Assistant Superintendents.

MR. H. WALKER Continued to act as Curator of the Geological Museum and Laboratory up to the 15th August 1924. Granted combined leave for two years and four months with effect from the 16th August 1924.

MR. K. A. K. HALLOWES	On combined leave for two years and four months with effect from 21st December 1923.
DR. A. M. HERON	Granted combined leave for 8 months and 9 days and permitted to proceed on leave from the field on the 21st March 1924. Returned from combined leave and resumed duty at Bombay on the afternoon of the 2nd December 1924. Appointed to officiate as Superintendent from the same date. Placed in charge of the Rajputana Party and left for the field from Bombay on the 4th December 1924.
DR. C. S. FOX	Returned to headquarters from field work in the Central Provinces on the 26th May 1924. Appointed to officiate as Superintendent from the 22nd March 1924. Attached to the Central Provinces Party in connection with the re-examination of the coal fields in the Central Provinces and left for the field on the 21st October 1924.
RAO BAHADUR S. SETHU RAMA RAU.	Returned to headquarters from field work in Burma on the 20th May 1924. Attached to the Burma Party and left for the field on the 26th October 1924.
RAO BAHADUR M. VINAYAK RAO.	Returned to headquarters from field work in the Madras Presidency on the 18th April 1924. Posted to the Madras Presidency to continue the survey of Salem and Arcot Districts and left for the field on the 3rd October 1924.

MR. H. CROOKSHANK	Returned to headquarters from the field on the 12th April 1924. Granted leave on average pay for seven months and four days with effect from the 8th May 1924. Returned and resumed duty on the 15th December 1924. Attached to the Central Provinces and Central India Party and left for the field on the 20th December 1924.
MR. E. L. G. CLEGG	Attached to the Burma Party. From the 25th March 1924, carried out the simpler duties of the Officer in charge of the Party.
MR. D. N. WADIA .	Returned to headquarters from the field on the 1st July 1924. At headquarters.
MR. G. V. HOBSON	Returned to headquarters from the field on the 9th May 1924. Appointed Curator of the Geological Museum and Laboratory with effect from the 16th August 1924.
CAPT. F. W. WALKER	Attached to the Burma Party and remained in that province throughout the period.
MR. J. A. DUNN	Returned to headquarters from the field (Bihar and Orissa) on the 11th May 1924. Attached to the Bihar and Orissa Party; left for the field on the 20th October 1924.
MR. A. L. COULSON	Returned to headquarters from the field (Rajputana) on the 30th April 1924. Attached to the Rajputana Party and left for the field on the 19th October 1924.

MR. E. J. BRADSHAW .	Returned to headquarters from the field (Assam) on the 5th May 1924. Left for Asansol on the 19th July 1924 to superintend the excavation of the fossil tree unearthed there and returned to headquarters on the 15th August 1924. Attached to the Rajputana Party and left for the field on the 1st December 1924.
MR. C. T. BARBER	Returned to headquarters from field work in Burma on the 21st April 1924. Attached to the Burma Party and left for the field on the 14th October 1924.
MR. E. R. GEE	Deputed for geological survey work to the Andaman Islands and left for the field on the 4th January 1924. Returned to headquarters on the 13th May 1924. Attached to the Central Provinces and Central India Party and left for the field on the 21st October 1924.
MR. W. D. WEST .	Returned to headquarters from the field (Central Provinces) on the 26th May 1924. Attached to the Central Provinces and Central India Party and left for the field on the 9th November 1924.
MR. A. K. BANERJI	Placed on special duty in England in connection with the British Empire Exhibition 1924 up to the 4th December 1924. Assigned to the Central Provinces and Central India Party.

DR. M. S. KRISHNAN Appointed Assistant Superintendent, Geological Survey of India on the 19th December 1924. Attached to the Bihar and Orissa Party.

Chemist.

DR. W. A. K. CHRISTIE . Left headquarters on the 5th January 1924 to investigate the salt resources of the Sambhar Lake and returned on the 18th January 1924. Granted leave on average pay for seven months and eleven days with effect from the 25th April 1924. Returned and resumed duty on the 8th December 1924.

Artist.

MR. K. F. WATKINSON . At headquarters up to the 1st June 1924. Granted leave on average pay for seven months with effect from the 2nd June 1924.

Sub-Assistants.

MR. B. B. GUPTA . . Returned to headquarters for recess from field work in Burma on the 4th September 1924. Attached to the Burma Party r left for the field on the 9th Novembe 1924.

R. D. S. BHATTACHARJI Returned to headquarters from field work in the Central Provinces on the 22nd April 1924. Attached to the Central Provinces and Central India Party; left for the field on the 20th October 1924.

MR. B. C. GUPTA .	. Returned to headquarters from field work in Rajputana on the 30th April 1924. Granted leave on average pay for six weeks with effect from the 21st August 1924. Attached to the Rajputana Party and left for the field on the 19th October 1924.
MR. H. M. LAHIRI	Attached to the Bihar and Orissa Party to investigate the monazite sand deposits on the Orissa Coast and left for the field on the 8th January 1924. Returned to headquarters on the 7th May 1924. At headquarters for palæontological work.
MR. L. A. NARAYANA IYER	Returned to headquarters from field work in Bihar and Orissa on the 16th April 1924. Granted combined leave for three months and eighteen days with effect from the 28th July 1924. Attached to the Bihar and Orissa Party and left for the field on the 26th November 1924.
MR. P. N. MUKERJEE	Appointed Sub-Assistant on the 13th September 1924. At headquarters.

Assistant Curator.

MR. P. C. ROY	. At headquarters.

The cadre of the Department continued to be 6 Superintendents, 22 Assistant Superintendents and one Chemist. Of the four vacancies in the grade of Assistant Superintendent existing in 1924 one was filled during the year, leaving at the end of the year three vacancies.

ADMINISTRATIVE CHANGES.

Promotions and appointments.

Dr. A. M. Heron continued to officiate as Superintendent up to the 30th July 1924 *vice* Mr. G. H. Tipper on leave; he was again appointed to officiate as Superintendent from the 3rd December 1924 *vice* Dr. G. de P. Cotter on leave.

Dr. C. S. Fox was appointed to officiate as Superintendent from the 22nd March 1924 *vice* Dr. J. Coggin Brown on leave.

Mr. H. Walker continued to act as Curator, Geological Museum and Laboratory, till the 15th August 1924, and thereafter Mr. G. V. Hobson from the 16th August 1924.

Dr. J. Coggin Brown continued to act as Palæontologist till the 21st March 1924 when he was relieved by Mr. H. C. Jones who acted till the 30th June 1924. Dr. G. E. Pilgrim succeeded Mr. Jones from the 1st July 1924.

Messrs. G. V. Hobson and A. L. Coulson have been confirmed in their appointments as Assistant Superintendents.

The following officer joined the Department during the year:—
Dr. M. S. Krishnan, Ph.D., D.I.C., A.R.C.S., appointed Assistant Superintendent on the 19th December 1924.

Babu P. N. Mukerjee, B.Sc. (Calcutta) was appointed Sub-Assistant on the 13th September 1924.

Babu A. K. Dey, B.Sc. (Calcutta) was appointed Field Collector on the 13th September 1924.

The following Museum Assistants were appointed during the year:—

Babu Austin Manindra Nath Ghosh, B.Sc. (Calcutta) on the 6th September 1924.

Babu Dasarathi Gupta, B.Sc. (Calcutta) on the 3rd November 1924.

Leave.

Dr. G. de P. Cotter was granted combined leave for two years and four months with effect from the 25th March 1924.

Dr. J. Coggin Brown was granted combined leave for one year and seven months with effect from the 22nd March 1924.

Mr. H. Walker was granted combined leave for two years and four months with effect from the 16th August 1924.

Dr. A. M. Heron was granted combined leave for eight months and nine days with effect from the 31st March 1924.

Mr. H. Crookshank was granted leave on average pay for seven months and four days with effect from the 8th May 1924.

Dr. W. A. K. Christie was granted leave on average pay for seven months and eleven days with effect from the 25th April 1924.

Mr. K. F. Watkinson was granted leave on average pay for seven months with effect from the 2nd June 1924.

Mr. B. C. Gupta was granted leave on average pay for six weeks with effect from the 21st August 1924.

Mr. L. A. Narayana Iyer was granted combined leave for three months and eighteen days with effect from the 28th July 1924.

LECTURESHIP.

Mr. H. Walker continued as Lecturer on Geology at the Presidency College, Calcutta, till the 15th August 1924 when he was replaced by Mr. D. N. Wadia.

POPULAR LECTURES.

Popular lectures were delivered in the Indian Museum during the year, the subjects selected being as follows :—

(1) "Salt" by Dr. W. A. K. Christie.

(2) "Meteorites" by Mr. H. Walker.

LIBRARY.

The additions to the library amounted to 4,630 volumes of which 1,269 were acquired by purchase and 3,361 by presentation and exchange.

PUBLICATIONS.

The following publications were issued during the year under report :—

Memoirs, Vol. XLV, part 2,
Records, Vol. LV, parts 2 and 4,
Records, Vol. LVI, parts 1 and 2,
Palæontologia Indica, New Series, Vol. VII, Memoir No. 4,
Palæontologia Indica, New Series, Vol. IX, Memoir No. 1.

MUSEUM AND LABORATORY.

Staff.

Mr. H. Walker was Curator of the Geological Museum and Laboratory from the beginning of the year to the 15th August. On the 16th August Mr. G. V. Hobson assumed the duties of Curator. Babu Purna Chandra Roy retained the Assistant Curatorship throughout the year. Babu Abani Kumar Dey acted as Museum Assistant from the beginning of the year until promoted to Field Collector on 13th September, the vacancy caused thereby being filled by the appointment of Babu Dasarathi Gupta on the 3rd November. The second post remained vacant until Babu Austin Manindranath Ghosh was appointed on the 6th September.

Chemist.

Until his departure for Europe on leave in April Dr. W. A. K. Christie, Chemist, was chiefly engaged with the routine work of the laboratory. He visited the Sambhar Salt Lake in January to advise on questions connected with tube-well borings. This is referred to under the heading Salt.

Determinative work and Analyses.

The number of specimens referred to the Curator for examination and report was 574. Assays and analyses were made of 35 specimens. The corresponding figures for 1923 were 237 and 44 respectively. The specimens analysed were largely coals but included limestones, clay and monazite.

Donations to Museums, etc.

During the year under review presentations of geological specimens were made to the following :—

(1) American Baptist Union Hall High School, Rangoon.
(2) Department of Geology, Edinburgh University.
(3) Great Indian Peninsula Railway, Bombay.
(4) County Secondary School, Clay Cross, England.
(5) Victoria Museum, Karachi.
(6) M. G. Horder, Bristol, England.

In addition to the above general presentations the following donations were made :—

(1) Specimen of Beldongrite with Spessartite to the Museum of Mineralogy, Toronto, Canada.
(2) Specimen of Itacolumite to the Physical Laboratory, Toulouse University, France.

(3) Typical specimens of Bauxite to the Director of Industries, Travancore.

Meteorite Collections.

During the period under review specimens of the Merua, Ranchapar, Sultanpur, Atarra and Cranganore meteorites have been sent to the British Museum, and specimens of the Shergotty, Shalka and Manbhum meteorites to the *Muséum National d'Histoire naturelle*, Paris. Specimens of the meteorites from Djati-Penjilon, Ngawi district, Java, and from El Tlahi, have been received from the *Muséum National d'Histoire naturelle*, Paris, and incorporated in our collections.

Additions to General Collections.

The material sent last year to the British Empire Exhibition has been returned and will be incorporated in the collections of the Department in due course.

In addition to the large number of rock and mineral specimens collected by members of the Department during the year the following specimens have been received and included in the collections :—

(1) Specimen of bitumen from Letpanchaung, Burma. Presented by Mr. A. Subba Iyer.
(2) Specimens of cassiterite from Amherst District, Burma. Presented by the Talaing Tin Co., Ltd.
(3) Specimens of graphite from Ceylon. Presented by Messrs. H. Rolfe & Co.
(4) Specimens of quartz sand for glass making. Presented by the Calcutta Mineral Supply Co.
(5) Briquettes of French and Italian lignites. Presented by Commander Heneage.
(6) Briquette of Welsh coal. Presented by The Minerals Separation Co.
(7) Specimens of chabazite from Pennsylvania and Bohemia; thomsonite from Scotland; and stilbite with chabazite from Pennsylvania. By exchange with the Academy of Natural Science, Philadelphia.

Burma Laboratory.

During 1924, 45 specimens have been received and reported upon of which 3 were quantitatively examined. The corresponding figures for 1923 were 29 and 3 respectively.

BRITISH EMPIRE EXHIBITION.

The exhibit of minerals, rocks, maps, sections and photographs, sent by the Geological Survey of India to the Wembly Exhibition in England, has been highly appreciated and has called forth unstinted commendation in the technical Press. It has done much to dispel the ignorance of the general British public regarding the mineral resources of this country, and has drawn particular attention to the importance of such Indian minerals as mica, manganese, lead, silver, wolfram, monazite and iron-ore; with respect to the coal, petroleum and gem industries, there was less need for advertisement. The exhibits which attracted the most general attention were the flexible sandstone (itacolumite), the specimens of mica—especially the large book of that mineral--, the large blocks of rock-salt, specimens of asbestos, and the iron-castings from the Bengal Iron Company. School parties were more especially interested in the mineral map.

Coming to the more serious aspect of the Exhibition, over fifty enquiries were made from British, Continental and American firms dealing with mineral products and from persons, mostly British, in a small way of business, anxious to expand their connections and develope along new lines. Sixteen of the enquiries were foreign, and came from the following countries :—

America	3	France	1
Germany	3	Holland	1
Belgium	2	Italy	1
Austria	1	Japan	1
Czechoslovakia	1	Sweden	1

Switzerland . 1.

The following table classifies them according to the minerals to which they relate, and brings out the prominence of mica and manganese-ore. Curiously enough asbestos comes third in importance, indicating an increased demand :

Mineral	No. of Enquiries.	Mineral.	No. of Enquiries
Mica	10	Slate	2
Manganese-ore	8	Spelter	1
Asbestos	7	Gypsum	1
Iron-ore and pig-iron	5	Ochre	1
Chromite	4	Sillimanite	1
Magnesite	4	Copper	1
Marble	4	Petroleum	1
Antimony	2	Corundum	1
Lead	2	Orpiment	1
Coal	2	Ilmenite and Monazite	1

The exhibits of pig-iron, iron castings and iron-ore from the Bengal Iron Company, Limited, drew attention to the possibility of importing iron-castings, pig-iron and iron-ore from India. Enquiries related mostly to prices of different grades of pig-iron, and were referred to the Bengal Iron Company, but there were two instances in which the proposition was the possible importation of iron-ore from India to England. Information was obtained for the benefit of enquirers regarding ocean freight from India and the approximate railway freight of iron-ore to Calcutta from Manharpur and Gurumaisini. Quotations from the Peninsula and Oriental Steam Navigation Company and the Bengal-Nagpur Railway Company, Limited, shewed that with iron-ore (rubio), 50 per cent., *ex* ship Tees, at Rs. 22 a ton, which is the price quoted on the 3rd October, 1924, the proposition would not be a feasible one. Trade in pig-iron between the United Kingdom and India shews prospects of development and there was a significant enquiry regarding pig-iron from a South African firm in Durban.

The enquiry regarding sillimanite is of interest as it came from two representatives of the Refractories Manufacturers' Association of the United States of America. The Research Section of the Association in the University of Pittsburg (Mellon Institute) has been experimenting with sillimanite and has reported it as very satisfactory for certain purposes; their reperesentatives came over specially to obtain information about the Indian deposit and to arrange for regular supplies.

Another enquiry was from an Italian firm at Trieste for addresses of exporters of Indian coal which they require for bunker purposes on Italian steam-ships.

Mr. A. K. Banerji discussed with the head of a firm of marble merchants the possibility of introducing Indian marbles into the British Isles. On obtaining the prices of Italian and Belgian marbles of different varieties and quotations of freight from Bombay, it was seen that it would be difficult for Indian marbles to compete with Belgian, Italian and Grecian material.

The Geological Survey exhibit has now been dismantled and divided more or less into two portions. One portion, consisting of rare and irreplaceable specimens, has been packed and returned to the Calcutta collections which were temporarily despoiled in order to render the exhibit as complete as possible. The other portion, consisting largely of specimens of economic interest of which duplicates

can easily be obtained, and of maps, sections and photographs, has been handed over to the Imperial Institute in compliance with a desire expressed by Her Majesty the Queen.

The following are the specimens which have been handed over to the Imperial Institute :—

Registered. No.	Description.	Locality.
30-29	Pisolitic Bauxite . . .	Ranchi district, Bihar and Orissa.
30-40	,, ,, ...	,, ,, ,, ,,
841	Compact Bauxite . . .	Belgaum district, Bombay.
733	Lateritic Bauxite . . .	Amarkantak, Central India.
30-63	Laterite	Palamau district, Bihar and Orissa.
L. 366	Stibnite in grey siliceous rock .	Southern Shan States, Burma.
M. 318	Orpiment	Chitral, N.-W. Frontier Province.
M. 319	Realgar with Orpiment . .	Aligot Mines, Chitral.
K. 271	Orpiment	Chitral.
10-151	Chromite	Salem district, Madras.
3,445	,, ...	Singhbhum district, Bihar and Orissa.
3,438	Chalcopyrite	Singhbhum district.
M. 11	Oxidised Copper ore . . .	Mosaboni mine, Singhbhum district.
L. 253	Copper ore	Bhagalpur district, Bihar and Orissa.
M. 420	,, ,, ...	Bawdwin mine, N. Shan States.
9-378	Auriferous Quartz . . .	Kolar, Mysore State.
F. 111	,, ,, ...	Nilgiri district, Madras.
K. 815	Galena vein with oxidised copper compounds.	Santhal Parganas, Bihar and Orissa.
L.-264	Galena with Cerussite and Tremolite.	Santhal Parganas.
H. 325	Galena with quartz and ochre .	Cuddapah district, Madras.
55-23	Limonitic clay ironstone . .	Palamau, Bihar and Orissa.
H. 110	Manganiferous clay ironstone .	Narsingpur, Central Provinces.
F. 139	Pisolitic Limonite . . .	Jubbulpore district, Central Provinces.
F. 178	Hæmatite	Hyderabad.
M. 287	Folded Hæmatite . . .	Singhbhum district.
31-608	Banded Iron Ore . . .	Singhbhum district.
M. 417	Large mass of Hæmatite	Pansira mine.
	Pig iron	Bengal Iron Co., Ltd., Kutti.
L. 3307	Cassiterite.	Mergui district, Burma.
L. 964 L. 965	Cassiterite pebbles . . .	Hermingyi, Tavoy district.
L. 407	Wolfram with quartz . .	Tavoy district.
863	Corundum crystals in granite .	Zanskar Range, Kashmir.
9192	Corundum	Hunsur, Mysore.
M. 1551	Garnet Crystals . . .	Nellore district, Madras.
L. 962	Borax	Tibet
3,297	Gypsum	Magwe district, Burma.
J. 279	Selenite	Rann of Kachh (Cutch).
	Graphite	Travancore.
M. 50	Crude Magnesite . . .	Salem, Madras.

Reg. No.	Description.	Locality.
3358	Triplite	Gaya.
I. 390 I. 391	Phosphatic nodules . . .	Trichinopoly, Madras.
13-537	Columbite	Nellore, Madras.
3360	,, ...	Gaya.
	Silica brick	Kumardhubi Fireclay Works.
L. 971	Apatite Magnetite rock . .	Singhbhum.
I. 555 I. 662	Celestine	Trichinopoly. Mari Hills.
M. 323	Levigated Yellow Ochre . .	Manufactured by Messrs. Turner, Morrison & Co., from crude ochre, Katni district.
M. 324	Golden yellow paint . . .	Manufactured from levigated, ochre, M. 323, by Messrs. Turner, Morrison & Co., Calcutta.
M. 159 M. 160	Cut Mica	Varalaksmi mine, Mangalpur, Nellore district.
M. 167 M. 170	,, ,, ...	Tellabodu mine, Nellore district, Madras.
M. 176	,, ,, ...	Palamani mine, Nellore district, Madras.
M. 206	,, ,, ...	Kubera mine, Nellore district, Madras.
M. 236	,, ,, ...	Kalichedu mine, Nellore district, Madras.
M. 243	,, ,, ...	Kandali mine, Nellore district, Madras.
M. 24	Dark phlogopite	Travancore.
M. 25	Light coloured phlogopite . .	,,
M. 30	Monazite sand	,,
M. 29	Zircon sand	,,
M. 28	Ilmenite sand	,,
M. 26	Garnet sand	,,
M. 292 M. 299 M. 300	Roofing Slates	Kangra Valley, Punjab.
L. 985	Enamelled Slate strips . .	Kharakpur Hills, Bihar and Orissa.
L. 986	Plain polished Slate strip . .	,, ,, ,, ,,
L. 994	Roofing Slate	,, ,, ,, ,,
I. 140	Steatite	Marble Rocks, Jubbulpore district, Central Provinces.
M. 264	Rock Salt	Salt Range, Punjab.

Coal. A representative collection from the various coalfields of India.

M. 299	Hard Coke	Loyabad by-product plant.
M. 280	Coal Tar	,, ,, ,, ,,
M. 281	Sulphate of Ammonia . .	,, ,, ,, ,,

The credit for the success of the exhibit must be given in the first place to Dr. Coggin Brown, who superintended its assemblage in Calcutta, and in the second place to Mr. A. K. Banerji, who took charge of it and of its display in London.

PALÆONTOLOGY.

Dr. J. Coggin Brown continued to act as Palæontologist up to March 22nd, when Mr. H. C. Jones assumed the duties of the post up to June 30th, and Dr. G. E. Pilgrim for the remainder of the year. During the year under review, two Memoirs have been published in the *Palæontologia Indica* :

(1) The late Captain R. W. Palmer's "A Description of an incomplete skull of Dinotherium, with notes on the Indian forms" as Vol. VII, Memoir No. 4 of the New Series.

(2) Dr. L. F. Spath's "Review of the Blake Collection of Ammonites from Kachh in the British Museum" as Vol. IX, Memoir No. 1 of the New Series ;

while the following papers of palæontological interest have appeared in the *Records* :—

(1) Fossil Molluscs from the Oil-Measures of the Dawna Hills, Tenasserim. By Dr. N. Annandale.

(2) On some Fossil Forms of Placuna. By the late E. Vredenburg.

(3) On the Phylogeny of some Turbinellidæ. By the late E. Vredenburg.

(4) Note on an Armoured Dinosaur from the Lameta Beds of Jubbulpore. By Dr. C. A. Matley.

Mr. C. Forster Cooper's memoir on the "Anthracotheriidæ of the Dera Bugti Deposits of Baluchistan," and Dr. G. E. Pilgrim's "Perissodoctyla of the Eocene of Burma" will form respectively Vol. VIII, Memoir Nos. 2 and 3 of the *Palæontologia Indica*, and will, it is hoped, be ready for issue almost simultaneously with the present report. The first part of the late Mr. E. Vredenburg's monograph on the Mollusca of the post-Eocene Tertiary formations of N.-W. India will appear soon after as *Memoirs*, Vol. L. This contains descriptions and figures of 56 new species or varieties, and a briefer mention of 34 species identified with Javan or Burmese forms and of 33 of D'Archiac and Haime's and Sowerby's types from Indian localities. The remainder of the monograph includes a description of some 65 new species or varieties, 26 identities with Javan or Burmese fossils, and 59 species which have been described and figured by D'Archiac and Haime or Sowerby. The specimens on which Mr. Vredenburg was engaged were left in considerable disorder through

his recent ill health and final illness. It has therefore been necessary to devote considerable time to the sorting out and arranging of them. Mr. H. M. Lahiri is now engaged on this work. Many of the plates have been partially prepared, and it is expected that those of such of the species as still remain to be figured will be finished before the end of 1925, when the second part of the monograph can be published. The same author's review of the genus *Gisortia* will be published shortly.

The calcareous alga collected by Mr. Vredenburg from the Ranikot beds of Sind forms the subject of a paper by Mr. John Walton, M.A., of Manchester. It will shortly appear in the *Records*. The specimens had originally been studied by Mr. B. B. Gupta, and his notes and photographs have been utilized by the author. The species is assigned to the genus *Triploporella* (family *Dasycladaceæ*), hitherto described from the Jurassic and Cretaceous of Europe. A tendency towards simplification of the vegetative parts of the plant, as we pass from the older to the newer forms, is remarked.

Two papers on fossil fresh-water mollusca by Dr. Baini Prashad will also shortly be published in the *Records*, one on a fossil Ampullariad from Poonch, Kashmir, and the other on a collection of land and freshwater fossil mollusca from the Karewas of Kashmir, which were made by Mr. W. J. Wright of the Whitehall Petroleum Company in the course of his geological work in Kashmir in 1920 and kindly presented to the Geological Survey. The latter have been carefully worked out by Dr. Baini Prashad and include a Zonitid belonging to the genus *Bensonia*; a *Hydrobiid*, which is regarded as a variety of the widespread *Bithynia tentaculata* Linn; a Planorbid, referred to *Planorbis* (*Gyraulus*) *pankongensis* (Nevill) v. Martens, and probably a *Corbicula*. The most interesting, however, is a Unionid, which almost certainly belongs to the genus *Lamellidens*; this family has not hitherto been recorded from Kashmir, either living or fossil.

The entire collection of *Unionidæ* in the Geological Survey collection, including forms ranging from the Cretaceous to the Pleistocene, has been handed over to Dr. Baini Prashad for study. Some new species have been noticed, while the hitherto described species are being revised and generically arranged according to the modern classification. The memoir, when completed will be published in the *Palæontologia Indica*.

Among the late Mr. H. S. Bion's papers were notes on Cretaceous fossils from Afghanistan and Khorassan including the collections of the late C. L. Griesbach, and on a few forms collected by the late Sir H. H. Hayden in Afghanistan and the late W. T. Blanford in the neighbourhood of Dera Ghazi Khan. These have been put into shape for the press by Dr. J. Coggin Brown, and will form the subject of a short paper in the *Records*. The most remarkable feature of the fauna is its strong European affinity, not only in the case of the lamellibranchs, which are the dominant class represented, but also by the occurrence of the typical European echinoid genera *Micraster* and *Cyphosoma* of the Cenomanian. The range of the species described in the paper is from the Vectian to the Campanian.

Mr. F. R. Cowper Reed's memoir on the Upper Carboniferous fossils from Chitral and the Pamir collected by Sir H. H. Hayden in 1914, will very shortly appear as Vol. VI, Memoir No. 1 of the New Series of the *Palæontologia Indica.* It contains descriptions of some 130 species, many of which are identical with forms that occur in the Schwagerina stage and to a less extent in the Cora stage of the Urals, and are characteristic of the uppermost beds of the Upper Carboniferous. The fauna is entirely different from any which has so far been found in other parts of India or in Kashmir, and, according to the author, affords evidence that an arm of the great Eurasiatic Mediterranean Sea of Upper Carboniferous times stretched across Chitral into Turkestan and Central Asia. The Zewan beds of Kashmir and their equivalents elsewhere are of later date than these Fusulina limestones of Chitral.

The discovery of large fossil tree trunks in the Lower Gondwanas near Asansol was mentioned in the last General Report. During the past year, one of these has been excavated by Mr. E. J. Bradshaw, assisted by Mr. P. N. Mukerjee. With the kind co-operation of the East Indian Railway authorities, this was transported safely in sections to the Indian Museum, Calcutta. These sections are now being partially re-cemented and mounted for exhibition in the corridor north of the Museum quadrangle. The trunk, as it stands, is 70 feet long, but there is evidence of an additional 23 feet, which was present where the trunk was originally embedded. It is, therefore, one of the largest fossil trees found in the world, comparable in size with the "*Pinites brandlingi*" found at Wideopen near Gosforth, about five miles north of Newcastle-upon-Tyne in 1831; this trunk measured 72 feet in length and was found in a grit towards

the top of the English Coal Measures.[1] As the Asansol trunk was entirely devoid of roots, branches and leaves, it appears not to have grown *in situ*. The coarse sandstone in which it lay belongs to the Panchet stage of the Lower Gondwanas. Mr. E. J. Bradshaw has contributed a short paper on the discovery, to which has been added a preliminary palæontological description by Prof. B. Sahni based on a few sections cut from fragments taken at random. It is referred to the genus *Dadoxylon*, and is possibly the same as one of the species previously described by Miss Holden. The genus is presumed to belong to the family of the *Cordaitales*, because of the association of wood of the same type with the characteristic leaves of the family. In this case, it may have borne the leaves described under the name of *Cordaites* (*Nœggerathiopsis*) *hislopi*, Bunbury.

Dr. Schilder has submitted a critical review of Vredenburg's "Classification of the Recent and fossil Cypræidæ," published in *Records*, Vol. LI, part 2 (1920). He points out that many of the species, in accordance with the rules governing geological nomenclature, should have other names than those which Mr. Vredenburg assigned to them, while in the case of certain other species he disagrees with Vredenburg's identifications. It is proposed to publish this as a paper in the Records as soon as possible.

A paper by Mr. D. N. Wadia on a skull of *Stegodon ganesa* obtained from the Siwaliks of Jammu has been accepted for publication in the *Records*. The specimen is in the Prince of Wales College, Jammu, and is remarkable as possessing a tusk 10½ feet in length and in a perfect state of preservation.

During the period of his study-leave in Europe, Dr. G. E. Pilgrim has been partially engaged in a study of the fossil Indian *Suidae*, in the course of which he examined the various types from the Siwalik hills contained in the British Museum, as well as most of the European species belonging to the family. The recognition of ancestral forms of *Potamochœrus* and *Sus* in the Middle Miocene horizon of Chinji—*i.e.*, at a much earlier date than they occur in Europe—has led him to hold a view as to the origin and classification of these genera different from that published in 1900 by Dr. H. G. Stehlin in his memoir, "Ueber die Geschichte des Suiden-Gebisses." Dr. Pilgrim regards the European Miocene *Suidæ* belonging to the genus *Palaeochoerus* and *Hyotherium* as representing a terminal branch,

[1] J. Lindley and W. Hutton; Fossil Flora of Great Britain, p. 7 (1831-3).

quite distinct from that of *Sus* and *Potamochœrus*. He cites the presence in the males of these European Miocene forms of a lower canine of a pronounced *Sus scrofa* type as a proof of this, since the Middle Miocene Indian forms, so far as is known, possessed male canines of a type nearer to that of *Sus verrucosus*, which Dr. Pilgrim regards as more primitive. This line did not migrate to Europe until the Middle Pliocene. Dr. Pilgrim has classified the *Suidæ* mainly by the lower premolars, and on this basis he proposes new generic names for the species belonging to the *Hyotherium simorrense* type, for the type of *Sus giganteus* and for Indian species which resemble *Hyotherium sommeringii*, but have male lower canines tending towards the *Sus verrucosus* type. Other generic names have been proposed for aberrant forms on the line of *Sus* (*sensu stricto*). The memoir, which embodies these views and which contains a description of many specimens which have been collected in India during the last 15 years, has been accepted for publication, and as the plates which illustrate it are now in course of preparation, it is hoped that it may be published in the *Palaeontologia Indica* during the present year.

The entire collection of Jurassic Ammonites from Kachh made by Mr. J. H. Smith, along with Waagen's types of the Kachh Ammonites (*Palaeontologia Indica*, Series 9, Vol. VII), have been despatched and will shortly be in the hands of Dr. L. F. Spath, who will proceed to study them at once.

Dr. Pilgrim visited Nurpur in the Kangra district in April, to investigate a discovery of fossil bones. These were found to be Rhinocerotid in character, and evidently belonged to a single individual. A week was spent in excavation, in the hope of finding the skull, but in vain; the bones were too fragmentary to warrant even a generic determination. *Hipparion* teeth occurred in the vicinity, which confirms a previous opinion that the horizon lies at the very base of the Middle Siwalik.

Amongst the specimens added to the collections in addition to those brought in by the Survey Staff, the following may be mentioned :—

(1) Tertiary fossils from the Saw oilfield, Burma; presented by Mr. A. Subba Iyer.

(2) Tertiary fossils from Java; presented by Mr. E. Parsons.

(3) A cast of *Daunichthys gregorianus* from Mepale oil shale, Burma; presented by Prof. J. W. Gregory.

(4) Skeleton of a fossil snake from the Irrawaddy series of Burma; presented by the Burmah Oil Company.
(5) A collection of specimens and casts of European fossil mammals; presented by Prof. H. G. Stehlin of Basle.
(6) A skull of *Tetraconodon* from the Siwaliks of Jammu; presented by the Prince of Wales' College, Jammu, Kashmir.

Advantage has, as usual, been taken of the library and fossil collections of the Geological Survey by various private geologists, who have visited Calcutta, especially in order to work out their own collections. Every endeavour has been made to facilitate their researches, as a result of which, more than one paper has been accepted for publication by scientific societies.

PETROLOGY.

Deccan Trap lavas of Bhusawal.

During the recess period of 1924 Dr. Fermor has examined microscopically the core specimens obtained from the Bhusawal boring (see *Rec. Geol. Surv. Ind.*, LIV, p. 19), which reached a total depth of 1,217½ feet. The section of lavas studied is from 46½ to 1,165 feet from the surface, or a thickness of 1,118½ feet in all. In this vertical section through horizontally-bedded Deccan Trap basalts 29 flows have been identified, ranging in thickness from 5 to 97½ feet and averaging 40 feet excluding the top and bottom flows, of which the full thickness was not represented.

The flows are all of basaltic composition, and the primary minerals present are in every case, labradorite, enstatite-augite, iron-ore, and glass. No fresh olivine has been detected, but no less than 19 of these flows contain iddingsite, or serpentinous, delessitic or other pseudomorphs after olivine.

The secondary or later minerals in these flows are numerous, comprising, besides the altered forms of olivine mentioned above, palagonite, chlorophæite, celadonite, delessite, chabasite, heulandite, mesolite (?), chalcedony, opal, quartz, the rare form of silica, lussatite, and calcite. The first four minerals have all in places been formed by the hydration and alteration of the primary glass, often with the participation of the iron-ore and augite, and more rarely with that of the labradorite. Of palagonite there are two chief

varieties, brown and green ; the brown is but an impure and possibly more ferruginous variety of chlorophæite, whilst the green may be in part either delessite or celadonite. The chabasite occurs in only two of the flows and appears to be formed as a complementary mineral to chlorophæite.

With the exception of the palagonite and chabasite all the remaining minerals are found as linings or infillings to vesicular or geodic cavities. Dr. Fermor has numbered the flows from 1 to 29 from above downwards. The characteristic zeolite is heulandite, which has been detected in no fewer than 21 out of the 29 flows. The chabasites in flow 25 and the heulandite and quartz in a geode in flow 27 contain internal evidence of formation at somewhat elevated temperatures (200° to 300° C.), and as heulandite is commonly one of the latest of all the minerals enumerated, these flows seem to provide evidence that nearly all the minerals were formed at temperatures higher than those characteristic of meteoric waters, and therefore to suggest that palagonitisation and the infilling of geodes and vesicles are to be regarded as parts of a late-magmatic series of changes, due to residual magmatic water, and taking place during the cooling of the flows after the original consolidation. The very latest of all these minerals is calcite, which alone to them can in some cases be regarded as probably of meteoric origin.

A study of the distribution of the various minerals within the flows indicates that each flow varies from top to base not only in vesicularity and texture, but frequently also in the proportion and distribution of the primary minerals. The distribution of olivine and of large microscopically visible labradorite phenocrysts is of particular interest, for the two minerals tend to occur together although the association is not invariable. Some flows are non-porphyritic and also as a rule devoid of olivine. The richly porphyritic flows on the other hand tend to contain olivine and can be divided into two groups : those in which the labradorite phenocrysts and the olivines have remained suspended, and those in which both have sunk. In the basal flows 29 to 26 both minerals are abundant and have remained in suspension. Flow 25 is a special type rich in chlorophæite and chabasite, only moderately porphyritic, with scarce olivine, and obviously derived from a different source to the lower flows. Flows 24 to 21 contain but a small proportion of felspar phenocrysts and but scarce olivine, and on the

whole neither mineral has sunk. But flows 20 to 14 are rich in porphyritic felspars, which have sunk and are specially abundant in the basal sections of each flow, occasionally constituting as much as 15 or even 20 per cent. of the rock. Olivine is scarce, having been detected in only two of the flows, and then, as might have been predicted, at the base. Comparing the two sets of richly porphyritic flows 29 to 26 and 20 to 14, Dr. Fermor suggests that in spite of the greater abundance of olivine in the lower set, they may have been derived from the same reservoir, in which case the difference between the two sets of flows must have been mainly one of viscosity. The later set (20 to 14) was evidently sufficiently fluid for gravity to cause differentiation within the flow after eruption, and both felspars and olivines (where present) have sunk, indicating that the specific gravity of the molten basalt was less than that of labradorite (about 2·70). In the case of the earlier set of flows the fact that the felspars have not sunk does not necessarily mean that the lava when molten had a higher specific gravity than in flows 20 to 14, for the olivines should still have sunk, the specific gravity of the matrix of flow 29 even when solid being only 2·93; whilst with any considerable increase of the density of the molten lava the felspars should, of course, have risen to the top of the flow. If it be assumed that the magma was more viscous at the time of the earlier set of eruptions than at the later period, the scantier olivine in the later set of flows is explained by the hypothesis that much of the olivine sank in the reservoir before the eruption of the fluid lava.

ECONOMIC ENQUIRIES.

Asbestos.

Kaolai, Ajmer; Rajputana.

One mile north-east of Kaolai, in the Ajmer sub-division, near the Marwar frontier west of Ajmer City, a band of serpentine in crystalline limestone has been worked for asbestos, in a large open-cut. Dr. Heron reports that the asbestos is in veins ramifying through the serpentine, the largest being about ¼ inch wide. Evidently the small proportion of asbestos present, in proportion to the country-rock, and its shortness of fibre, have precluded successful exploitation.

Building Materials.

Salem and Arcot districts, Madras.

Some of the limestone bands of the Dharwars in the Salem district near Samalpatti and Dasampatti railway stations and near Kagankarai railway station in the North Arcot district are described by Mr. Vinayak Rao as marbles suitable for building and ornamental purposes. *Kankar* is found in most of the plains at the foot of the hills. Most of the rocks in this area form excellent building material. In the valleys near Alangayam, west of Bisanattam and South of Tirupattur, clays of recent deposits found in the plains are suitable for brick-making.

Coal.

Janitia Hills ; Assam.

In the Jaintia Hills of Assam, near the village of Sutnga and in other places, Mr. E. J. Bradshaw visited some of the sporadic outcrops of coal in the Cretaceous series. The coal itself is of good quality, but the seams are thin and interbedded with slaty shales and sandstones. In places the coal is almost a lignite. Occurrences are few and variable, the usual mode being small horizontal pockets scattered over wide areas. The seams may thin out from 3 feet to 3 inches in a short distance. A rough analysis of a picked sample from a pocket north of Laphet yielded :—

Fixed Carbon	50·60
Volatile matter	41·54
Moisture	2·20
Greyish ash	5·66
	100·00

Mergui District ; Burma.

Mr. S. S. Rau visited the coal outcrops near Plaw-aw (98° 56′ 30″ ; 10° 57′ 30″). These are made up of thin seams interbedded with carbonaceous black shales and thin stringers of resin in Tertiary rocks. The coal is poor in quality and of limited extent (*vide Sel. Records Govt. India*, No. X, 1856, pp. 48—50).

Copper.

In the Ye-Yaman Tract of the Kyaukse district, Burma, azurite and malachite are found as vein minerals, associated with barytes, in both the Plateau Limestone and the Sindetaung shales (see p. 50). Mr. C. T. Barber, who examined the occurrences, reports that at two localities unprofitable attempts have been made to work them, but that the veins are too small and impersistent to encourage the hope that further attempts will prove successful.

Ye-Yaman Tract; Burma.

A vein of copper ore was found by Mr. B. B. Gupta 2½ miles S.W. of Longyi (24° 45′ 40″; 94° 4′ 55″) just over the Pakokku Hill Tract boundary. At the surface malachite occurs but on opening up the vein copper pyrites is seen impregnating serpentine. An analysis of a piece of impregnated serpentine gave 11·1 per cent. copper.

Longyi, Pakokku Hill Tract; Burma.

Engineering Questions and Allied Enquiries.

At the request of the Chief Engineer, Western Command, Mr. H. C. Jones examined the Siwalik conglomerates and sandstones in the area connected with the hydro-electric scheme near Urak, north-east of Quetta. Mr. Jones considers that percolation should not be large, and that from a geological point of view, there seems no reason why the scheme should not be a success.

Hydro-electric scheme, Quetta; Baluchistan.

In January Mr. J. A. Dunn received orders to investigate the Khora Valley reservoir site in Shahabad with a view to advising on the suitability of the foundations. It was found that the rocks in the bed of the stream at the only economically suitable place for a dam were folded into a series of shallow anticlines and synclines. After a careful examination of the site and of sections of the rocks, it was concluded that all weaknesses could be avoided and a strong foundation ensured by giving the alignment of the dam a downstream curvature. This necessitates the erection of a hollow-barrel type of reinforced concrete structure which will be founded on a thick bed of quartzite on the south side of the crest of a shallow anticline,

Dam-site, Khora Valley.

Dam-site, Kyatkon, Myingyan district; Burma.

At the request of the Public Works Department (Irrigation) of Burma Captain F. W. Walker inspected a second dam-site at Kyatkon in the Myingyan district. The site crosses the Kyaukpon Chaung which, in the vicinity, follows the boundary between silicified tuff on the south and volcanic agglomerate on the north. These are the two formations on which the dam will rest, and both are considered suitable for the scheme. No section showing the actual junction between the two formations is exposed and it is probable that soft beds intervene, through which the stream has been able to cut a channel. The boundary may also be faulted. To determine the nature of the concealed beds and the possibility of faulting, boring with a calyx drill has been recommended in the stream bed.

Dam-site, Panlaung; Burma.

The Panlaung River rises in the hills of the Southern Shan States and for the greater part of its course flows through a gorge in the Plateau Limestone and associated formations. It emerges into the Irrawadi valley near the village of Ingon, and from this point onwards natural levees have been built up so that the level of the river is above that of the surrounding country. Floods are consequently very prevalent in this region during the monsoon, and much damage is frequently caused to property, including the important main line of the Burma Railway. To control the flood waters of the Panlaung and prevent such damage, it is proposed to construct a dam at Nyaunggyat, some 15 miles south of Ingon and 36 miles S.S.E. of Kyaukse, where a sharp turn to the west carries the Panlaung River through the granite outcrop, which here flanks that of the Plateau Limestone on the west. Mr. C. T. Barber, who was deputed to examine the dam-site reports that the granite is kaolinised to a considerable depth but that there appears to be no insuperable objection to the construction of a dam at this site. It must be borne in mind, however, that the action of water on the kaolinised granite will produce a clay with a very low coefficient of friction, and foundations must be sufficiently deep to prevent any possibility of slipping. On the flanks of the dam where the greatest depth of kaolinised rock is to be found, it may not be imperative to penetrate to the fresh rock for foundations, so long as due regard is paid to the above principle, since the pressure on the flanks of the dam will be considerably less than that against the centre. Being a flood dam leakage by percolation is of inconsider-

able importance, provided no water enters the base of the dam or exerts an upward pressure in the foundations.

As the granite in the immediate vicinity of the site is considerably kaolinised, it will probably be advantageous to fetch granite for construction material from Dananbyu, some four miles distant, where the rock is quite fresh and free from shattering, and where an abundance of suitable stone is easily accessible without the expense of working off an overburden of useless decomposed material. Good materials for the manufacture of cement are not locally available, and this necessity will have to be brought from elsewhere.

Garnet.

Sarsiri, Ajmer ; Rajputana.

At Sarsiri, a village in Ajmer belonging to the Raja of Pisangan, 5 miles from Mangliawas Railway Station (16 miles south of Ajmer Junction) is a deposit of massive garnet which might be useful for abrasive purposes. Dr. Heron reports that the country rock is dense, tough, dark-green, banded granulite, interbanded with white crystalline limestones. The garnet is reddish-brown and massive, forming some 15 irregular bands more than 1 foot in thickness, with innumerable smaller lenticles and vein-like bodies.

The largest band, north of Sarsiri, is from 6 to 12 feet wide, forms an outcrop 15 feet high in places, and can be traced running vertically along the strike for about 300 yards. This is not solid garnet from wall to wall, but includes streaks of quartz, calcite, a green ferromagnesian mineral, and country rock, but garnet forms roughly $\frac{4}{5}$ of the whole. Loose blocks, 2 or 3 feet across, of almost pure garnet, are strewn in dozens all along the outcrops of the chief bands. Sarsiri is connected with Mangliawas Station by a semimetalled road over flat country, and ample labour is available from large villages near at hand.

Gold.

Salem.

Mr. Vinayak Rao remarks that the Dharwar band extends along the N.W. corner of the District in sheet $57\frac{1}{5}$ into Salem and has several quartz veins which might be tested for gold. It is probable that the main lode of Kolar has been faulted in this direction.

Iron.

Rajputana.

Mr. A. L. Coulson had occasion to inspect some of the occurrences of limonite and hæmatite associated with the limestone bands of the Aravalli Hills between Deoli and Bundi. He remarks on the close proximity of the ferruginous masses, some of which have been worked for a long period of time, to "newer pegmatite" intrusions (see p. 66).

Kaolin.

Jaintia Hills, Assam.

In several places in the Sutnga area in the Jaintia Hills, Assam, there are occurrences of a very fine and pure, white kaolin which would be suitable for pottery. Unfortunately there is no local demand, and the cost of transport to an outside market would prove prohibitive.

Thaton District, Burma.

Towards the end of March Captain F. W. Walker paid a short visit to Yinnyein, Thaton district, to report on the quantity of kaolin available there. It was, however, found that too little prospecting work had been done to enable an estimation of quantity to be made.

Pakokku, Burma.

Deposits of China Clay were noted by Sub-Assistant B. B. Gupta about half-a-mile N.W. of Letpan (20° 15′; 96° 6′) and half-a-mile S.W. and S.S.W. of Gwegyi (20° 9′; 96° 8′) (*vide* Gen. Rep. for 1919, *Rec. Geol. Surv., India,* Vol. LI, pp. 14-15). Their exploitation has not proved commercially possible.

Magnesite.

Salem, Madras.

Mr. Vinayak Rao reports the presence of magnesite over a low hill 3 miles south of Samalpatti Railway Station in Salem, forming a network of veins.

Manganese.

Chhota Udaipur and Panch Mahals; Bombay.

Mr. Hobson reports that during the past ten or fifteen years considerable development has been carried out on the manganese deposits in Chhota Udaipur and in the Panch Mahals. Work is being done by the Shivrajpur Mining Syndicate at Shivrajpur and

Bamankua in the Panch Mahals and at Pani in Chhota Udaipur. At the former place work has now been carried down to a depth of over 100 feet and in the latter to upwards of 50 feet over a varying width up to 40 feet, the lateral extent of these workings being about 2 miles.

It is reported that the manganese reef has been proved more or less continuously, following the western and northern slopes of the high ground from Shivrajpur to Pani a total distance of about 14 miles. An eastern extension from Pani was not proved. Mr. Hobson examined an occurrence of black rock pointed out by a villager at Chetapur and found this to be manganese. This point is some five miles east of Pani on the approximate extension of the strike.

At Bamankua considerable quantities of "float" ore are dealt with. At Pani occasional patches of pyrolusite are met with from which an extremely high-grade ore, running over 90 per cent. pyrolusite, is obtained. The reef at Pani has suffered very considerable distortion; the centre portion has been folded in a vertical plane and has the shape of a very flattened S with the ends extending in parallel but displaced directions. At the extreme eastern end of the working there appears to have been folding in a horizontal plane.

The original mono-railway from Champaneer Road to Shivrajpur has been replaced by a narrow-gauge line and this has more recently been extended to Pani.

Nagpur and Bhandara; Central Provinces.

During his work in the Nagpur and Bhandara districts of the Central Provinces, Sub-Assistant D. Bhattacharji examined exposures of manganese-ore and gondite. A search for the continuation of the Aswalpani I (Garka Bhonga) manganese band between the Ambagarh range and the main watershed has shewn that this band does not cross the Garra-Heti-Alesur road.

Mica.

Ajmer-Merwara, Rajputana.

Mica was observed by Mr. A. L. Coulson in the Ajmer-Merwara sub-division of Ajmer-Merwara, Rajputana, in the "newer pegmatites." Numerous small pits had been worked during the Great War when there was a demand even for poor quality mica. Only one mine of

any size, $2\frac{1}{2}$ miles N.-W. of Shokla (26° 13′; 74° 54′) was being worked at the time of inspection.

Monazite.

Ganjam district, Madras.

Mr. H. Crookshank examined some of the sands along the coast in the Ganjam district, Madras, between the Chilka lake and the Chicacole river. He states that there is a large number of deposits of natural concentrates, consisting mainly of ilmenite, monazite, zircon and garnet, but the deposits are small. The monazite-content of some of the richer of these natural concentrates was estimated at about 5 per cent. Mr. Crookshank is of opinion that large quantities of concentrates could be collected along the coast, but is doubtful of the possibility of the Ganjam sands competing with the Travancore and Ceylon sands. Perhaps the increasing demand for the by-deposit, ilmenite, may eventually make the working of the deposits a remunerative proposition.

Cuttack district, Bihar and Orissa.

Sub-Assistant H. M. Lahiri carried out an investigation of the sands of the portion of the Orissa coast between the mouths of the Myapura Mohanna and the Mahanadi river in the Cuttack district. He collected, concentrated and examined a large number of samples from about 25 miles of the mainland coast, and from about 8 miles along the Dowdeswell and False Point coasts. Naturally concentrated deposits of black sand occur along the mainland coast, having an average width of about 55 feet and a thickness of less than a foot. The average monazite content of these natural concentrates does not seem to exceed 2·5 per cent., although a few small local deposits contain from 8 to 12 per cent. of monazite. The richest samples from the sand dunes yielded only from 1 to 2 per cent. of the mineral. The naturally concentrated black sands of the Dowdeswell and False Point coasts are patchy in character, and extend for about 8 miles with an average width of about 40 feet and a thickness of 6 inches or so. The black sand is poorer in monazite than that of the mainland coast and does not appear to contain more than 1 per cent. of monazite. These percentages of monazite in the sands compare unfavourably with that of the Travancore sand, where the average is 10 per cent., and the richest sands yield up to 60 per cent. Ilmenite is, however, plentiful in the natural concentrates of the Orissa coast.

Oil-shale.

Mergui district; Burma.

At Htawphan (98° 57′ 30″; 11° 18′) near Bonkun Mr. S. S. Rau records low-grade oil-shale, poor in quality and of limited extent, outcropping in the eastern bank of Zenya Chaung.

Petroleum.

Rawalpindi, Punjab.

On the crest of a tightly compressed anticline, among steeply inclined almost vertical Murree strata, a new petroleum spring (33° 45′; 73° 16′) was found by Mr. D. N. Wadia about 15 miles N. E. of Rawalpindi. The oil has here saturated a patch of gravel in a stream-course, coating the gravel with bitumen and a yellow wax.

Salt.

Sambhar Lake, Rajputana.

Great improvements have recently been made at the Sambhar salt source, not only in connection with extraction, transport and storage, but especially in stabilising output and guaranteeing an average supply of salt even in a year of scanty rainfall. This last result, due mainly to Mr. S. A. Bunting, Executive Engineer in charge of the development scheme, has been effected by building a substantial dam across the Lake dividing it into two parts, one about eighty-five square miles, the other, called the main reservoir, between five and six square miles. Powerful pumps have been installed at this dam to transfer to the main reservoir the water brought down by the rivers in the monsoon after they have dissolved the superficial salt crust from the lake bed. Even with a rainfall much below normal, enough brine is banked up against the dam by the prevailing south-west wind to enable a sufficient supply to be pumped into the reservoir before the main body of the Lake dries up. The brine is allowed to concentrate before being transferred, either directly or through so-called condensers, to crystallising pans near the shore.

With a monsoon such as that of 1923, however, when, in spite of a nearly normal total of seventeen inches, the rainfall was so evenly distributed that a much larger proportion than usual was absorbed by the sand covering most of the drainage area, the amount

of water available is barely sufficient for requirements. To meet contingencies of this kind it was proposed to supplement the supply of water or brine from fifteen-inch tube wells sunk in the lake bed. The abortive result of preliminary trials with these led the Commissioner, Northern India Salt Revenue, to ask for advice on their proposed further development. Dr. W. A. K. Christie therefore visited the Lake in January. On *a priori* grounds the success of tube wells was not probable. Calyx drill borings made in the lake silt in 1904 had shown the underlying rock in each of the widely separated borings to be mica schist. The schist of the neighbourhood is too compact to carry much water, while too abundantly folded to be likely to have any definite direction of underground drainage. The layer between silt and undecomposed rock seemed more promising, but experimental evidence was against this. It was difficult to tell from the triturated material recovered whether the well then being sunk had yet reached the massive schist or not. Boulders of a distinctively coloured hornblende schist, dropped down the well and subjected to the same treatment, yielded, however, a similar *débris* ; there was no doubt that the well was already in massive schist. Observations of the rate of flow of brine in it were entirely disappointing. The tube well project has been abandoned.

Maurypur Works, Karachi.

During August Mr. J. A. Dunn was deputed to investigate the supplies of salt brines in the neighbourhood of the Maurypur Salt Works, about 8 miles to the west of Karachi. The brines at the Salt Works are raised from shallow wells sunk in the flat Moach Plain just at the limit of the high spring tides. On first working, the brines are sub-soil accumulations which are saturated salt solutions, and these may be found down to a depth of 4 feet. When once these are worked out the supply of brine in the wells is, according to Mr Dunn, dependent upon sea-water percolation. There is a progressive lateral concentration of such percolating sea-water caused by evaporation at the surface. The supply of brines is, however, limited by the rate of seepage, and this cannot be increased to any great extent. To do so would merely lower the concentration out of all proportion to the yield. It was calculated that 3,000 to 3,500 maunds of salt per acre could be expected by very skillful working, so that from the 1,800 acres available an annual yield of 55-65 lakhs of maunds seems possible It was suggested that lines of trenches 200 feet apart should be cut between lines of wells to assist percolation of sea-water. It

was also suggested that the direct treatment of sea-water would prove a more profitable method.

Tin.

Mergui district, Burma.

Rao Bahadur Sethu Rama Rau reports that tin ore is worked at the following places in the Mergui district of Burma during the rainy season, water being then available for sluicing the hill slopes and working the alluvial flats:

1. Yengan and Khechaung mines, N. of Yengan Creek—Survey Sheet 96 $\frac{I}{15}$ (98° 47½′, 11° 27½′).
2. Migyaung Chaung—Sheet 96 $\frac{I}{10}$ (98° 44′, 11° 25′).
3. Inner Bokpyin (Atwin Bokpyin) mines—Sheet 96 $\frac{I}{5}$ (48° 48′, 11° 14′).
4. Yanngwa—Sheet 96 $\frac{I}{16}$ (98° 48′, 11° 7′).
5. Hangapru—Sheet 96 $\frac{I}{16}$ $\frac{I}{8}$ (98° 47′, 11° 1′).
6. Huachaung—Sheet 96 $\frac{I}{16}$ (98° 48′, 11° 18′).
7. Tuttwe—Sheets 96 $\frac{I}{12}$ and $\frac{I}{8}$ (98° 44′, 11° 4′).
8. Taungkamet—Sheets 96 $\frac{I}{12}$ and $\frac{I}{8}$ (98° 44′, 11° 8′).

In addition to these localities ore occurs in the mangrove swamps north of Tuttwe and south of Taungkamet, but its value has not yet been proved, whilst some alluvial flats in the Huachaung, Bokpyin-Yangwa, and Hangapru valleys have not yet been prospected.

The tin ore is found in association with (1) decomposed pegmatite containing muscovite, cassiterite and small quantities of tourmaline and garnet, (2) quartz veins in association with the younger granites which extend into the adjoining slates and quartzites of the Mergui series, and (3) greisen formed on the fringe of the granites. These rocks are all particularly liable to disintegration owing to the kaolinisation of the felspar constituent, and the products are deposited upon hill slopes and alluvial flats where they are worked.

Local purchase and smelting of the tin ore by Chinese methods are carried out at many places, *e.g.*, at Bokpyin (Atwin) where there are three furnaces and at Hangapru where there are two. The ore mixed with charcoal is heated in cylindrical blast furnaces, the blast being supplied by two cylindrical wooden blowers set horizontally. The matte is drawn off through a tap at the base of the furnace, cast into ingots and despatched to Mergui or Penang.

Water.

Mr. H. C. Jones examined the deep boring which is being put down at Kasi, near Quetta, and agrees with Mr. R. D. Oldham, the late Sir H. H. Hayden and Dr. G. de P. Cotter that the boring should be carried down to the basal gravels or to the solid bed rock of the valley floor, which has not yet been reached. The boring which was started in fairly high ground in the Quetta plain has been carried down to 1,223 feet, through silt and clayey material. A number of water-bearing bands were encountered in the first 500 feet, but below this the boring went through silt and clay material.

Quetta, Baluchistan.

Mr. Jones examined the Pishin area, Baluchistan, but did not consider the area at all favourable for artesian water supply.

Dr. C. S. Fox has submitted a report upon the resources of water supply for the town of Chhindwara in the Central Provinces, which at present derives most of its water from wells and some from tanks. To cope with the demands of an increasing population Dr. Fox considers a storage supply such as a reservoir in a perennial stream the most satisfactory arrangement. The most obvious projects worth consideration in this connection are dams in any of the following rivers or streams, the Bodri, the Kulbehera, or the Sadedeo.

Chhindwara, Central Provinces.

In response to a request from the Director of Military Works, Army Headquarters, Mr. D. N. Wadia was deputed to investigate the water resources of Kohat, Bannu, Dardoni and Manzai in the North-West Frontier Province. The limestone of Eocene or Mesozoic age, forming the hills which surround the Kohat plain, is an aquifer of enormous capacity feeding a number of perennial springs of large calibre. Mr. Wadia concluded that an adequate and reliable source of good water, sufficient for the requirements of Kohat in times of peace as well as of war, exists in the Jangal Khel group of springs. An alternative scheme would be to dig wells of large diameter in the strip of gravel-strewn country lying between the Fort and the Rifle Range. A third possible site is the bed of the Toi river along its western bank. The principal water-bearing bed of Kohat is within easy reach of the surface at these localities, and is reported to be likely to yield water under semi-artesian conditions. Tube wells are not recommended in view of the thick coarse gravel.

Kohat, N.-W. Frontier.

The problem at Bannu and Dardoni was found to be different. These stations stand upon vast spreads of gravel and shingle belonging to the old deserted beds of the Kurram and its tributaries. These features make for rapid absorption of the surface water and its transference underground through the thick zone of sponge-like gravel. The underground water table at Bannu is about 140-170 below the surface, and at Dardoni it is 150 feet. At these depths wells have low recuperative powers. Tube-wells are out of the question in such thick gravels, and the digging of additional wells will not greatly augment the yield. The remedies suggested by Mr. Wadia are (1) to deepen the existing wells 10 or 20 feet, or (2) to drive galleries or headings of about 10-15 feet in length in radial directions in the saturated zone of gravel just below curb level.

Bannu & Dardoni, Waziristan.

Manzai stands on a boulder conglomerate of Pleistocene age which forms a subsidiary watershed between two water-courses—the one on the west being 300 feet, and that on the east 500 feet, lower than the level of the camp. The depth of level of permanent saturation must, under these circumstances, be beyond ordinary well-boring operations. The site of the Manzai camp is therefore extremely unfavourable from the point of view of underground water-supply. Mr. Wadia found it difficult to suggest any improvement on the present arrangement of bringing water from the Tankzam river at Khirgi, 5 miles to the N.W., although it involves the maintenance of a post at Khirgi and a guard for the 5 miles of exposed pipe-line. The Tankzam water is free from any organic impurities, but is often discoloured by mechanically-held silt. It would be difficult to construct settling tanks in the bed of this river owing to its frequent violent spates.

Manzai, Waziristan.

GEOLOGICAL SURVEYS.

At the suggestion of the Chief Commissioner, Andaman and Nicobar Islands, Mr. E. R. Gee was deputed to continue the geological investigation of this group of islands commenced by Mr. Tipper twenty years ago. In addition to survey work on Middle Andaman, the following areas were visited :—Rutland Island and Little Anda-

Andaman and Nicobar Islands.

man Island, Ritchie's Archipelago, the Nicobar Islands including Great Nicobar Island.

The southern part of Rutland Island, which had been visited by Mr. G. H. Tipper, consists mainly of altered basic intrusions—largely serpentine rocks. The northern part of the island is composed mainly of grey micaceous sandstones with intercalated shales, dipping to the west at a fairly high angle. Little Andaman Island, to the south is extremely low-lying with very few exposures around the coast. The island appears to be composed largely of raised coral of recent age, which is well exposed at Hut Bay in the south-east. At Jackson Creek, however, in the north-west of the island, cliffs of micaceous cavernous green-grey sandstone and argillaceous sandstone, dipping to the E. at a low angle, are exposed; from these beds two types of *Pecten* were obtained.

Ritchie's Archipelago, situated to the east of the Andamans is composed entirely of sedimentary strata. The rocks vary from the shelly sandstones of Sir Hugh Rose Island and of Neill Island, the predominating white clays and marls of Havelock Island, John Lawrence Island, and Henry Lawrence Island, to the ferruginous shelly sands of Outram Island.

Strait Island and Colebrook Island to the north-west of the Archipelago Group were also visited. The former is composed of sandstones and shales with bands of conglomerate, steeply folded, and striking N.—S. Colebrook Island consists of white marls in its eastern portion, while the south-western promontory is of green sandstones associated with a pink porcellanous limestone and basic intrusives, corresponding to the rocks of the main Andaman Group. The junction between the eastern and western series is hidden by mangrove-swamp.

Long Island, N. Passage Island and Guitar Island consist of white sandstones and clays similar to the main Archipelago Group.

The beds of Ritchie's Archipelago yielded a very rich fauna. From the ferruginous sands of S. E. Outram numerous well-preserved gastropods, lamellibranchs, and several foraminifera, together with two species of corals were obtained. Several of these species were identical with Dr. Noetling's Pegu types from Burma. The conglomerates of Strait Island yielded several types of fishes' teeth, also comparable with the Mid-Tertiary fossils of Burma. From the clays of S. W. Havelock Island a few fragile specimens were obtained indicating a similar horizon. The sands of the S. W.

point of Neill Island yielded two types of echinoids, *Marctia* spp. and *Temnopleurus* spp. and several species of *Pecten.*

The main Archipelago Group, therefore, appears to be of Mid-Tertiary age. It is probable that the two southern islands—Sir Hugh Rose Island and Neill Island—are composed of more recent strata since the echinoid, *Marctia*, obtained from them varies only slightly from the living species, *M. planulata*, now existing in the Andaman seas. Further investigation will, doubtless, add to the identified species and allow a more exact determination of the horizon of these beds.

Kar Nicobar, Chaura, Camorta, and Tilanchong Islands were visited by Mr. Gee. The three former islands consist essentially of light grey clays, practically unfossilliferous, and similar to those of Ritchie's Archipelago. The low-lying parts of the islands are, however, of recent raised coral. Tilanchong and the Cinque Islands consist largely of basic intrusions, a peridotite with bronzite being prominent.

A short visit was paid to Galatea Bay in the extreme south of Great Nicobar Island. The rocks were all sedimentaries, consisting of sandstones and grey clays, the former with fragments of lignite; they resemble the sediments of the main Andaman Group.

As was to be expected, the types of rocks met with in Middle Andaman Island are very similar to those described from North and South Andaman. According to Mr. Gee two main series are represented: (*a*) a basic igneous series, (*b*) a sedimentary series.

(*a*) The basic igneous rocks range from coarse peridotites, through types of hypabyssal affinities to andesites and basalts showing definite flow-structures. The peridotites, mainly enstatite and augite types in which the olivine and occasionally the augite also has been largely altered to serpentine, are most predominant. Small quantities of chromite and picotite occur in these rocks. These peridotites form considerable masses in the hilly districts of the eastern and central parts of the island, and are associated with andesites and andesitic-tuffs. A grey metamorphosed sandstone, almost a quartzite, also occurs in these areas, but is distinct from the main sedimentary group. Red and yellow jaspers also occur. At several places serpentinous dykes appear to occur in the main sedimentary series, but owing to the abundant vegetation their relations are obscure.

(*b*) In the sedimentary series arenaceous types are prevalent, but argillaceous strata are usually intercalated and are locally

predominant. The arenaceous group includes sandstones, largely micaceous, and conglomerates. The latter vary considerably in texture, the most common variety being composed of medium-sized pebbles of white quartz, hard grey quartzite, red jasper, and basic igneous rocks. They are often slightly carbonaceous with a few badly-preserved plant-remains. In the river-bank, about $2\frac{1}{2}$ miles north of Bomlung-ta two small intercalations of coal occur in the clays. In the north-west of Middle Andaman Island a grey foraminiferal limestone occurs in the series. The arenaceous beds of the sedimentary series are unfossiliferous, and the clays, containing only ill-preserved plants, afford little information. However, from the limestone of the north-west, the characteristic nummulite—*Nummulites planulatus*—has been recognised, indicating a Lower Eocene (Ranikot) horizon for these beds.

That the igneous series belongs to an earlier age is indicated, firstly, by the occurrence of pebbles of these rocks in the conglomerates of the sedimentary series, and secondly, by the unmetamorphosed occurrence of the latter in areas neighbouring the igneous intrusives. It is possible, however, that hypabyssal intrusion continued after the deposition of some of the sandstones, producing the above-mentioned dyke-intrusions. The main period of igneous-activity, however, was of Pre-Tertiary age.

Jaintia Hills; Assam.

Mr. E. J. Bradshaw continued the survey of the Shillong Plateau. Between the months of January and May he surveyed a portion of the Jaintia Hills in the south of the plateau connecting up areas surveyed in 1900-1902 by Bose and in 1882 by LaTouche. In many places observation is difficult on account of the dense jungle and the broken nature of the country, so that work is necessarily slow and the field evidence often slight.

Almost all the rock series of the plateau are encountered in this area, but the problem of the relationship of the various systems to one another is complex. The ancient gneiss of the plateau is only exposed in the beds of rivers to the south. Mr. Bradshaw's interpretation of the succession is that in early times the Shillong rocks were intruded by epidiorite—the Khasia Greenstone of Medlicott—and that later there came a great intrusion of granite to the north. The latter rock is foliated to the south, parallel to the east-and-west strike of the Shillong series. Mr. Bradshaw considers it probable that the foliation is not due to subsequent

stress, but was induced originally, at the time of intrusion, when the rock was in a semi-molten condition. The granite was intruded into, and is younger than the epidiorite, but the dykes of dolerite which sometimes replace the schists of the Shillong series are younger than the granite.

From very early times the plateau has been an elevated land mass whose general topography was much the same as it is to-day. Upon the gently-sloping peneplain an invading sea crept northward, laying a deep but thinning carpet of sedimentary rocks whose age ranges from Cretaceous to Tertiary. The Cretaceous rocks have been divided into an upper and a lower group, both of which are conformable to the overlying beds, and consist for the greater part of horizontally-bedded sandstones. Argillaceous beds are common in the upper group, and coal, shale, and limestone are developed occasionally. The rocks of the upper group are distinguished from those of the lower by their calcareous tendency and by the fact that they are fossiliferous. They are most thickly developed along an old shore line in a period during which sedimentation was more or less stationary, so that the deposits are banked in old valleys and on the sides of hills and gorges.

The lower group is typically unfossiliferous, arenaceous, and littoral, and consists, not of one series thinning simply to the north, but of repeated sets of beds of ferruginous sandstones, fine-grained above, passing through argillaceous and often carbonaceous beds, to coarser grits and conglomerates below: Mr. Bradshaw dwells in some detail upon a curious indurated clay rock which is, in places, the basal bed of this group. He considers it to be the stratified cap of a rotting granite, though in two places it may possibly represent a much-altered lava flow.

The Tertiary rocks consist of nummulitic limestone and unfossiliferous sandstones whose differentiation from the lithologically similar Cretaceous sandstones is a matter of some difficulty where the limestone is absent. For the most part the beds are horizontal, but occasionally there is a slight dip to the south. The limestone is highly fossiliferous and at times is composed almost entirely of nummulites.

From the Tertiary limestone in the Jaintia Hills, Assam, Mr. Bradshaw collected teeth of *Oxyrhina* and dental plates of *Ptychodus*, sections of *Orbitoides*, and poor specimens of *Pecten*. Amongst the abundant nummulites the following genera were provisionally

recognised :—*Nummulites (Assilina) exponens, N. spira, N. atacicus, N. ramondi, N. (Asilina) leymerii.*

This fauna suggests a horizon equivalent to the Upper Chharat of the North-west Punjab, or to the Upper Laki or Lower Khirthar of Sind.

From the rocks of the Upper Cretaceous group a few poor specimens of *Ostrea, Turitella, Cerithium* (?) *Natica, Terebra*, and some corals were collected.

Bihar and Orissa.

During the field season 1923-24, the Bihar and Orissa party consisted of Mr. H. Cecil Jones (in charge), Messrs. H. Crookshank, J. A. Dunn, and Sub-Assistants H. M. Lahiri and L. A. Narayana Iyer.

Singhbhum district, Bihar and Orissa.

Mr. Jones continued the geological survey of the western portion of the Kolhan Government Estate in Singhbhum, to which reference has been made in previous General Reports, but his field season was shortened owing to his return to headquarters to take charge of office.

The geology of the area worked by Mr. Jones was of no outstanding interest, the strata consisting mainly of soft shales of varying types belonging to the upper part of the Iron Ore series. The variation is usually not distinctive enough to enable any particular band to be traced for any great distance, or the sequence in one part of the area to be compared with that of another. The variation is mainly one of colour, but on weathering most of the varieties take on a ferruginous appearance and become brownish in colour. They are often partially replaced by siliceous material. Thin bands or lenticles of quartzite occur in the shales, but these can only be traced for a few miles at most. The shales have a general strike between N.E.-S.W. to E.N.E.-W.S.W. and a general dip of 70° to 80° to the N.W. or N.N.W., but sharp local folding is common. These shales are overlain by a sandstone group which is marked by bands of conglomerate and thin bands of shale and phyllite. None of these bands, however, seems to be very continuous or traceable for any distance. These conglomeratic bands are well exposed near Tirilposi (Survey sheet 73 $\frac{F}{4}$), where they consist of well-rounded pebbles up to 8 inches in diameter of hard compact white or pale greyish quartzite, cemented together by a sandy matrix. Some of the phyllites also become

very conglomeratic in parts, but the pebbles are more angular and consist of pale grey quartzite and banded hæmatite quartzite with an occasional pebble of red jasper.

Mr. J. A. Dunn worked along the northern boundary of Singhbhum, in the Seraikela and Kharsawan States, and in the south of the Manbhum and Ranchi districts on Survey sheets $73\frac{F}{14}$, $\frac{F}{13}$, $\frac{F}{10}$, and $\frac{F}{9}$. The suggestion of the previous season that the boundary between the Iron Ore series and the metamorphics to the north was one of overfold and overthrust has been confirmed. Perhaps one of the most important results of the season's work has been to show that the Dalma traps are a series of volcanic flows, associated with which are abundant volcanic tuffs and breccias. The original basaltic rocks have become altered to epidiorites. These flows now occur in two belts, striking E.-W., and separated by a geo-anticline of mica schists. It is against the southern belt that the Iron Ore series has been overfolded and overthrust, and in this belt the epidiorites have for the most part been altered to chlorite and sericite schists. Overfolding has been from north to south so that the dips of the schists are invariably to the north. Along the southern boundary of the northern belt of volcanics the mica schists dip north, beneath the epidiorites, but on the northern boundary the dips vary from southerly in the eastern end, through vertical, to a northerly dip in the western end. The following succession may be made out along the two boundaries—

S. side of the lava flows.	N. side of the lava flows.
3. Lava flows with frequent agglomerates.	3. Lava flows with frequent agglomerates.
2. Thin, impersistent, carbonaceous and other phyllites, and quartzites.	2. Carbonaceous phyllites, purple shaly phyllites and quartzites.
1. Phyllites. Mica schists.	1. Grey phyllites changing to uncleaved quartz-felspar-biotite schists in the west, and with abundant tuffs. Mica schists to the north.

It is presumed from the similarity of these sequences that the metamorphic schists to the north and south of the northern belt of epidiorites may therefore be correlated. The Dalma volcanic flows accordingly represent the top of the metamorphic series, upon which Mr. Dunn considers the Iron Ore series was laid down and overfolded. The schists underlying the epidiorites are made up—to a large extent at least—of metamorphosed volcanic tuffs.

The following succession is now suggested by Mr. Dunn for Singhbhum :—

5. Newer dolerites (altering to epidiorites in the north).
4. Granites.
3. Ultrabasic igneous rocks.
2. Iron Ore series.
1. Older metamorphics.

The "older metamorphics" Mr. Dunn would correlate with the Dharwars on the following premises: They have been followed by intense thrust movements, such as in the Indian peninsula are associated only with the Dharwars. These thrust movements were associated with and followed by granitic rocks which are frequently gneissic. Following the overthrusting and acid intrusions there has been a series of basaltic intrusions, the rocks of which have in places been converted to epidiorites, contrasted with the fact that there has been no such intrusion of basaltic rocks between Cuddapah and Rajmahal times, and no epidiorites later than Cuddapah. Mr. Dunn would thus place the granites, the period of overthrusting and the Iron Ore series as successively older than the Cuddapah epoch. Between the older metamorphics and the Iron Ore series there is a pronounced unconformity as has already been noted by Mr. Jones, who suggested that the latter might be referrable to the Cuddapahs.

Whether the Metamorphic series to the north of, and thrust-faulted against, the Iron Ore series, is to be correlated with the metamorphics occurring in South Singhbhum has still to be decided. Lithologically, these metamorphics in the north, of which the Dalma Volcanic series is a part, are similar to those in the south, but it is possible that they represent merely a highly metamorphosed part of the Iron Ore series thrust-faulted against the unaltered representatives of that series.

The Chakradharpur granitic mass which has been intruded into the thrust zone of the southern belt of volcanics, may be shown to consist of at least two distinct intrusions. Occasionally the granite is gneissic, but generally metamorphism has imparted a schistose structure to the rock and there has been a certain amount of decrystallisation.

Sub-Assistant L. A. Narayana Iyer accompanied Mr. H. C. Jones for instruction, and training, and continued the mapping of Survey sheet 73 $\frac{F}{3}$, after Mr. Jones had returned to head-

quarters. The area mapped by him consists of shales of the upper part of the Iron Ore series, with occasional thin bands of quartzite.

Meiktila and Yamethin districts, Burma.

During the field-season 1923-24, Dr. G. de P. Cotter, geologically surveyed Sheets Nos. 84 $\frac{P}{13}$, 93 $\frac{D}{1}$, 93 $\frac{D}{2}$, and parts of Sheets 93 $\frac{D}{5}$ and 93 $\frac{D}{6}$. The first three sheets shew only Tertiary rocks and alluvium; the last two, which include the margin of the Shan Plateau, shew granites and other igneous rocks intrusive into a slate series, limestone referable to the Plateau Limestones, and a shale-sandstone-conglomerate series probably Rhætic-Jurassic in age.

The Tertiary area shews a series of unfossiliferous soft sands and sandy shales folded into anticlines and synclines, the axes of which trend about 15° W. of N. to 15° E. of S. A few pieces of fossil wood were found in the series, but no other fossils. Dr. Cotter is of opinion that the series should be regarded as Upper Pegu and not as Irrawadian in age, by reason of the continuation of the series into the Pegus near Mount Popa, without any traceable geological boundary separating them. In the Shan Plateau area, the oldest series consists of the slates and quartzites which occur near the edge of the hills and are exposed both west of Yinmabin railway station and also in the south of Sheet 93 $\frac{D}{6}$ in the neighbourhood of Nankwe village. These slates and quartzites are regarded as identical with the Chaung-Magyi series of LaTouche.

The igneous rocks which are intrusive into the local representatives of the Chaung-Magyi series are mainly gneissose granites, with subordinate bands of intermediate intrusives, including felsite porphyry and augite lamprophyre. The belt of Chaung-Magyi rocks and intrusive granites occupies the outer margin of the hills. Near Pyinyaung station sedimentary rocks of more recent age occur, and rocks of probably Rhætic to Jurassic age are brought into juxtaposition with the granites, the junction possibly being faulted.

The Rhætic-Jurassic group consists of conglomerates, sandstones and shales, often red to purple in colour, and appears to rest unconformably upon the Plateau Limestones which are exposed east of Pyinyaung. There is a conglomerate of large boulders, including limestone boulders, along the junction; this is probably a basal conglomerate. Unidentifiable marine fossils were found about two miles north of Pyinyaung and appear to include one of the *Ostræidæ* as the main fossil. Near Pyinyaung station, there are traces of

fossil plants, but none is identifiable. Dr. Cotter regards the series as identical with the Coal Measures and Red Beds of Kalaw. Grey limestones referable to the Plateau Limestones are seen east of Pyinyaung and form the main hill range; no fossils were found in them.

The limestones just mentioned are apparently underlain by a series of sandstones and shales, possibly Silurian in age, but in which no fossils have so far been found. Much work is still necessary before the age and sequence of the rock groups of this interesting area can be determined.

Pakokku, Minbu and Thayetmyo districts, Burma.

Mr. E. L. G. Clegg working in the south-western parts of the Pakokku district and the northwestern parts of Minbu, over parts of Sheets 84 $\frac{K}{3}$, 84 $\frac{K}{4}$, 84 $\frac{K}{1}$ and 84 $\frac{L}{2}$ and in the Thayetmyo district over parts of Sheets 85 $\frac{I}{14}$, $\frac{I}{15}$, $\frac{I}{16}$, 85 $\frac{M}{2}$, $\frac{M}{3}$ and $\frac{M}{4}$ completed the geological survey commenced in the 1921-22 field season for the purpose of linking up the work of Dr. G. de P. Cotter, Mr. H. S. Bion, Rao Bahadur Sethu Rama Rau and Dr. Murray Stuart in the above-mentioned districts.

It was found possible by Dr. Cotter in the Pakokku district to subdivide the Eocene into :—

Yaw stage.
Pondaung Sandstone.
Tabyin Clays.
Laungshe series.
Paunggyi (Swelegyin) Conglomerate

whilst in the south Thayetmyo area Dr. Murray Stuart subdivided the rocks into :—

Plateau Gravels.
Kama Clay.
Upper Prome Sandstones.
Lower Prome Sandstones.
Sitsayan Shales.
Unconformity.
Nummulitics (Eocene).

All the subdivisions were recognised in the Pakokku area but it was found in mapping southwards that the Paunggyi Conglomerates are only locally developed towards the base of the Laungshe

series and could not be continued as a separate subdivision. It was also found that the separation of a Tilin Sandstone formation, which becomes impossible in Sheet 84 $\frac{L}{3}$, could only be accomplished with difficulty in Sheets 84 $\frac{L}{1}$ and 84 $\frac{L}{2}$.

The Laungshe series grades imperceptibly into lower strata through a region which has been subjected to great dynamic forces and the "Axial" boundary, in the absence of any more reliable data, has been taken to include inliers of crystalline limestone which protrude through shales of the boundary rocks, and isolated areas in which agglomerates, serpentine and lavas (amygdaloidal trachyte) occur.

In Sheet 84 $\frac{K}{4}$, the inner Dudawdaung fault which has been caused by a curious kinking of the Tilin Sandstones, describes an arc round the Seikpyu-Saw road and fades away east of Thigon. In Sinzu Chaung at a point three furlongs N. W. by W. of the Kyaukmyaung Rest House (21° 7′, 94° 12′) the only semblance of a fauna in this northern area was collected. It includes *Arca pondaungensis* Cotter, *Corbula* (*Bicorbula*) *semitorta* Bœttg. *Axinea* sp. allied to *Axinea purucnsis* Mart., *Melania* cf. *Faunus boettgeri* Martin. *Athleta* sp., *Cardita* sp., *Mactra* sp., and shows affinities with the Upper Eocene of Nanggulan.

In the South Thayetmyo area the Plateau Gravels of Stuart correspond to the Irrawadian group of more northern areas and it was not found possible to divide up the Prome Sandstones into an upper and lower series. No unconformity was recognised between the Sitsayan Shales and the Eocene.

The above boundaries were not continued north, as lateral variation made them very ill-defined, but an upper division of alternating strata underlain by a sandy series and the latter by a shaly one could be generally recognised.

As stated in the General Report of last year (1922-23) there is no well marked band whereby the Pegu series can be separated from the Eocene, and the boundary, which was fixed on palæontological evidence and is the only one available, is not very satisfactory owing to the unfossiliferous nature of the boundary rocks.

From one mile S. W. of Thakutkyaw (19° 17′ 40″, 94° 59′) in Sheet 84 $\frac{L}{15}$ where *Orthophragmina omphalus* Fritsch and *Orthophragmina papyracea* Boub. var. *Javana* (Maj. and Min.), definite Eocene species, were collected, to west of Thapangyo in Sheet 84 $\frac{L}{16}$, where Eocene limestones have been mapped by Dr. Murray Stuart, no faunistic

evidence for definitely fixing the boundary was available. The rocks of this area are folded into a series of anticlines and synclines on a general N.W.-S.E. strike.

Yamethin, Thayetmyo and Magwe districts, Burma.

Captain F. W. Walker was engaged from November to the middle of March in sheet-mapping the southern end of the Pegu Yomas. The tract of country covered lies west of the railway between Pyinmana and Thawutti and includes Sheets 94 $\frac{A}{2}$, 85 $\frac{M}{14}$, and 85 $\frac{M}{10}$. Alluvium covers a great part of Sheet 94 $\frac{A}{2}$ and is part of the Sittaung alluvial valley, along which the Irrawadi at one time made its connection with the sea. The high ground at Pyinmana is mainly composed of boulders and pebbles of quartzite, gneiss and schist, embedded in a whitish clay; this has been termed Older Alluvium. The remainder of 94 $\frac{A}{2}$ is covered with sandy gently-dipping beds which have a characteristic Irrawadian appearance. There is some doubt about their age owing to a scarcity of fossils, and to their gradual passage into Pegu strata on the west, without any distinct red or conglomeratic bed such as marks the boundary between Irrawadian and Pegus in the oilfields area. The few outcrops met with consist of sand-rock, soft sandstones and clay, with a dip seldom exceeding 20°. Practically no outcrops were found in the Irrawadian in Sheet $\frac{M}{10}$ where the surface is almost flat and the soil-cap thick. Gravel, *kunkar*, small ferruginous concretions and fossil wood are found in small quantities.

The fossil beds found near Lewe contain abundant specimens of a large *Batissa*, mostly with valves united. Some of the shells are hard and well preserved, due to the infiltration of calcareous matter, but the majority are soft and crumble into a fine, white powder during extraction. Several valves, both right and left, have been obtained which shew the hinge plates with teeth complete. Although exhibiting *Batissa* characteristics very plainly, some of the valves have *Velorita* affinities; one specimen, for instance, shews three oblique cardinals. The specimens differ from previously described species, but seem to be more closely related to *B. inflata*, Prime, although very much larger. They appear to belong to a new species. Associated with it, specimens of a small *Corbicula* and casts of a *Unio* were found. The fresh-water nature of the fauna is noticeable. West of the Yoma, a single fragment of a tortoise-shell was the only fossil found in the Irrawadian.

Pegu beds compose the main mass of the Pegu Yoma and have a regular N.N.W.—S.S.E. strike. They have been folded into irregular anticlines and synclines whose axes follow the same direction. Lithologically they are alternations of soft pepper-and-salt sandstones and bluish thin-bedded shales, in varying proportions. Thin bands of calcareous sandstones are found in parts, especially in a belt about two miles wide west of Dalangyun. Small faults and displacements are to be seen in nearly every section but only one fault of considerable size was mapped; it is a strike fault and is seen in the Mataungda and Yebu Chaungs south of Dalangyun. In the south of the area the beds have been much disturbed and contorted.

Captain Walker found the main area of the Pegu beds completely devoid of fossils; this, combined with the absence of any outstanding belt of shale or sandstone, has rendered a sub-division of the series impossible. For the same reason the correlation of beds in adjoining sections is uncertain, except in places where the folding is regular.

In the south of 85 $\frac{M}{10}$, a good fossil horizon was discovered in Pegu strata; it occurs about 3,000 feet below the Irrawadian boundary and, from a preliminary examination of the fauna, the Kama stage seems to be indicated. Minute lamellibranchs compose the greater part of this fauna, while a species of *Dendrophyllia*, with a few gastropods and fish teeth, make up the remainder. The following preliminary identifications have been made by Captain Walker :—

Lezin :

Tellina hilli, Noetl.
Mactra, sp.
Nucula alcocki, Noetl.
,, *phayreiana*, Noetl.
Cardita viquesneli, d'Arch. and Haime.
,, *mutabilis*, d'Arch. and Haime.
,, cf. *scabrosa*, d'Arch. and Haime.
Venus, sp.
Parrallelipipedum prototortuosum, Noetl.
Arca nannodes, Martin.
,, *burnesi*, d'Arch. and Haime, var *rotundata*.
Corbula socialis, Mart.
Arca, spp.

Pecten kokenianus, Noetl.
,, *irravadicus*, Noetl.
Ostræa papyracea, Noetl.
Tapes, sp.
Solarium maximum, Phillipi.
Ranella, sp.
Conus, sp.
Cylichna, sp.
Vermetus, sp.
Dentalium, sp.
Otolithus, sp.
Balanus, sp.
Dendrophyllia, sp.
Alopias vulpes, Gmel.
Carcharias (*Prionodon*), sp.
,, (*Aprionodon*), sp.
Oxyrhina pagoda, Noetl.

Techaung:

Tellina (*Metis*) *grimesi*. Noetl.
Tellina hilli, Noetl.
Nucula alcocki, Noetl.
Cardita viquesneli, d'Arch. and Haime.
Dione, sp.
Pecten kokenianus, Noetl.
Pecten, sp.
Ostræa papyracea, Noetl.
Dosinia protojuvenilis, Noetl.
Tellina, sp.
Arca metabistrigata, Noetl.
,, *myoensis*, Noetl.
Hindsia, sp.
Ranella (*Pseudobursa*) *promensis*, Vred.
Conus (*Lithoconus*) cf. *myaukmigonensis* Vred.
Oliva cf. *acuminata*, Lamk.
Oliva, sp.
Natica obscura, Sowb.
Solarium maximum, Phillipi.
Clavatula, sp.
Dentalium, sp.
Dendrophyllia, sp.

Balanus, sp.
Otolithus, sp.
Oxyrhina pagoda, Noetl.
Carcharias (*Prionodon*) *gangeticus*, Mand H.
" " *egertoni*, Ag.

There are no minerals of economic value in the area examined; even building stones and road metal are almost completely absent.

Meiktila, Yamethin and Magwe districts; Burma.

After an instructional visit to the Yenangyaung and Singu oil-fields, Mr. C. T. Barber was deputed to survey those portions of the Meiktila, Yamethin, and Magwe Districts, which are included in Survey of India sheets 84 $\frac{P}{10}$, $\frac{P}{11}$, $\frac{P}{11}$, and $\frac{P}{15}$. This area was found to be occupied for the most part by the Upper Pegus, consisting of alternating, soft, thin-bedded sandstones and sandy clays and shales, in which lateral variation is characteristic. These rocks are for the most part barren, but fossil fish teeth were discovered from four localities, and a few poorly preserved lamellibranchs and gastropods were also found. In the neighbourhood of the Irrawadian boundary, silicified fossil wood is locally abundant but is not characteristic of the Pegus as a whole. Throughout the area occupied by Upper Pegus, soda efflorescence is conspicuous in the *chaungs* and marshy places, and in many places the water is saline and sulphatic. The strike of the beds is N.N.W.—S.S.E. in direction, and the rocks are folded into a series of sharp anticlines and synclines.

In a broad syncline with its major axis passing through the village of Mypyagon (20° 36′; 95° 29′), the rocks possess a much greater lithological resemblance to the Irrawadi series than to the typical Upper Pegus, consisting of soft, whitish sandstones, containing abundant fossil-wood and calcareous root-like concretions. Mr. Barber describes the deposit as softer than the rocks of the typical Upper Pegus and as occupying a low-lying tract in which the peculiar type of earth sculpture characterising the Irrawadi deposits, is in sharp contrast to the topography of the typical Upper Pegus. The boundary between the two types of deposit is unconformable and is characterised by the presence of numerous thin bands of lateritic conglomerate. These beds, however, lie in the line of strike of the strata which Dr. Cotter is inclined to attribute to the Upper Pegu series. Rocks of the Irrawadi series again come in at the extreme south-west of sheet 84 $\frac{P}{11}$.

Practically the whole of the district, with the exception of a small area in the extreme north-east, is covered by Plateau Red Earth,[1] and the solid geology is only seen where this has been dissected by recent denudation. The Plateau Red Earth is a brick-red, sandy clay in which *kankar* is locally abundant; derived fossil-wood also occurs and is particularly abundant where the Red Earth overlies rocks of the Irrawadi series.

No products of economic value were discovered in this area, but attempts have been made to make bricks from the Plateau Red Earth, not, however, with any great success.

Ye-Yaman Tract, Kyaukse; Burma.

The Ye-Yaman Tract is a rugged and mountainous hill tract extending eastward from the level plain of the Kyaukse district, into the heart of the Shan uplands. It is an old plateau, which has been deeply dissected by ravines. The western portion of the area is occupied by Plateau Limestone, here a compact, slightly sandy, somewhat dolomitic limestone of a slaty blue colour. This rock extends in an easterly direction as far as the village of Chaungzon where it gives place to a series of shales, phyllites and sandstones, the "Sindetaung Shales" of Mr. Datta. Mr. Barber is of opinion that the Sindetaung Shales underlie the Plateau Limestone and further that the junction is one of considerable unconformity The sediments of the Sindetaung Shale series are characterised by a degree of metamorphism, the effects of which are not recognisable in the Plateau Limestone. In the absence of fossils the correlation of these sediments is uncertain, but they are described as having a strong lithological resemblance to the Chaung-Magyi series, in which every rock in the Sindetaung Shale series can be matched.

Mergui district; Burma.

Rao Bahadur Sethu Rama Rau continued work in the Mergui district, completing sheets 96 $\frac{I}{11}$, $\frac{I}{12}$, $\frac{I}{15}$, $\frac{I}{16}$ and the major portion of sheets 96 $\frac{M}{8}$, $\frac{J}{3}$, and $\frac{J}{9}$, thus bringing the geologically surveyed area down to latitude 10° 33′. The rocks met with consisted of Tertiary sediments, granite and members of the Mergui series.

The rocks of the Mergui series were found to be mainly composed of quartzites, grits, slates, shales, micaceous shales and phyllites, striking generally in a direction from 12° or 15° W. of N. to 12° or 15° E. of S., and highly folded and faulted. A peculiar metamor-

[1] Pascoe: *Mem. Geol. Surv. India*, Vol. XL, pp. 50—52.

phosed sedimentary rock resembling a granodiorite, and containing brown biotite, magnetic iron oxide and garnet with kyanite as a secondary product after biotite is exposed in the island of Pulo Kamat (98° 36′ 30″, 11° 0′ 30″).

Of the two granites recognised, the older, exposed in the Yangwa Range and in the islands extending from Pulo Sun to Pulo Dana, is a coarse-grained porphyritic biotite granite, which sometimes shews augen structure, when it has the appearance of a granitoid gneiss. This granite is not associated with the occurrence of tin ores.

The younger granite occurs as lenticular patches and veins of limited extent intruded generally into schists of the Mergui series, and occasionally into the older granite, and forms the matrix of the tin ore. It is mainly pegmatitic and contains among other minerals tourmaline, muscovite, garnet and cassiterite.

The Tertiary strata include shale (sometimes carbonaceous, sometimes with a little oil and gas), coal in association with resin, conglomerate and sandstone.

Yamethin district; Burma.

Sub-Assistant B. B. Gupta was engaged in mapping parts of the Yamethin and Pyinmana townships of the Yamethin district and completed sheets 93 $\frac{I}{4}$ and the major portion of sheet 84 $\frac{P}{16}$.

The formations mapped include Irrawaddy Sandstones and the Upper Pegu series and strike in a general N.N.W.—S.S.E. direction. Only in the Sintho Chaung section was a distinct boundary seen between the two series, and here arenaceous shales with subordinate sandstones of the older series appear to pass conformably into coarser sandstones of the newer.

In the southwestern area the Irrawadian shews faulting. Some *Batissae* having affinities with the existing form, *B. similis*, Prime, were noticed; fossil wood was scarce, and with the exception of the broken fragment of a tooth, vertebrate fossils were entirely absent.

The Upper Pegus are represented by a mixture of shales and sandstones of inconstant lithological characters in which fossils are almost absent; further subdivision is thus rendered impossible. Fossils were collected from the following localities only :—

(1) About three furlongs W. of Myetye (20° 5½′, 96° 2½′).
(2) Five miles S. W. of Thanbayagon (20° 12½′, 95° 50′).
(3) One-and-three-fifth miles N. of Sattobauk (20° 13′, 95° 58½′).

A calcareous sandstone forms the matrix in the first and third localities and in this indeterminable molluscan shells and bryozoa were noticed. Fish teeth having affinities with or related to *Carcharias* (*Prionodon*) *egertoni* Ag. were recognised from the third, whilst *Rotalia* was found in abundance in the second and sparingly in the first.

Chhindwara district. Central Provinces.

During the field season 1922-23 the Central Provinces party comprised Dr. L. L. Fermor (in charge), Dr. C. S. Fox, Messrs. G. V. Hobson and W. D. West, and Sub-Assistant Durgashankar Bhattacharji. Dr. Fermor resumed his survey of the Sausar tahsil, Chhindwara district, and of the adjoining portions of the Nagpur district. The formations encountered (sheets $55\frac{K}{14}$ and $55\frac{K}{15}$) were, as previously, alluvium, Deccan Trap, Infra-Trappeans, and Archæans. The chief interest lies in the latter.

Speaking generally, the Archæan rocks of this tract have been folded about axes with an E. S. E.—W. S. W. strike, and as there are several different lithological units in the Archæan succession the rocks tend to be arranged in belts corresponding with the successive anticlinoria and synclinoria. These belts, which begin in the Sausar tahsil, all strike towards the Nagpur district to the E. S. E. The most southern of these belts in the Chhindwara district is the broad belt of dolomitic marbles of the Khapa Padri Reserved Forest which is interpreted as a synclinorium in the form of an anticline with both limbs turned up. This is followed to the north by the Pareghat-Raiwari belt of calc-granulites regarded as an anticlinorium, the northern limb of which forms the southern limb of an exceedingly complex synclinorium commencing at Borgaon and Medi in the W. N. W. and extending through Mogra and the Sapghota Reserved Forest into the Nagpur district to the E. S. E.; this is referred to as the Mogra synclinorium. To the north of this lie other anticlinal and synclinal folds, often of considerable complexity, with associated overthrust faults.

In previous years Dr. Fermor has classified the stratified Archæan rocks of the Sausar tahsil in the following provisional order :—

Top 5. Hornblende-schists and amphibolites.
4. Serpentinous dolomitic marbles with marginal diopsidites.
3. Gonditic rocks and manganese-ores.
2. Calcitic marbles.
Base 1. Calc-granulites.

On this basis the belts referred to above are designated anticlinoria and synclinoria. It must be recalled that the intensity of the folding of the rocks is such that the folds are as a rule isoclinal, so that in many cases the only way of deciding between an anticline and a syncline is a study of the pitch phenomena. The difficulty of deciding the order of the sequence is increased by the possible recumbency of some of the folds.

The Mogra belt contains a set of rocks not hitherto found in any force in this part of India, namely a scapolitic facies of marbles and associated granulitic rocks. The Mogra synclinorium is about 1½ miles wide measured between the calc-granulites on either margin. Inside the calc-granulites on each edge are pink calcitic marbles, and between these marbles is a belt of exceedingly folded rocks—diopsidites, scapolitic granulites, biotite-gneisses, and hornblende-schists. Each of these rocks is repeated several times by folding, and as another set of folds oblique to the main folding has been superposed upon the whole sequence, there are some unusually complex structures, pitching as a rule at a high angle to the S. S. E.

It has been explained in a previous review (*Rec. Geol. Surv. Ind.*, LIII, p. 21) that the several members of the stratified succession are not commonly in contact, but are separated by biotite-gneisses that are intrusive but have been folded up with the stratified rocks and therefore dip conformably with them. It has also been explained that the calc-granulites were formed by the *lit-par-lit* intrusion of sheets of the acid magma along the bedding planes of the original limestone, the intrusive layers assimilating material from the invaded layers, and also adding material thereto. The dolomitic marbles on the other hand have suffered marginal metamorphism with the production of diopsidites and diopside-granulites, but they have resisted the intimate penetration that produced the banded calc-granulites from the calcitic marbles. It is not easily understood why there should have been this difference, as both sets of marbles seem equally massive.

The calc-granulites are occasionally scapolitic and it has been noted in previous years that the scapolite is found at the contacts with intrusive granite-pegmatites, but the phenomenon is quantitatively unimportant. In the cross-section of a portion of the Mogra synclinorium exposed in the watercourse S. E. of Mogra village, however, Dr. Fermor has found what appears to be a case of

intimate *lit-par-lit* intrusion of the dolomitic suite by an acid magma —that of the same fine-grained biotite-gneiss that formed the calc-granulites from the calcitic marbles. Allowing for presumed original differences of composition of the calcitic and dolomitic marbles we find analogous products. In the normal calc-granulites both the limestone and the intrusive layers have yielded primarily a rock composed of green pyroxene, felspar, and quartz, with sphene, but the felspar in the sedimentary layers is labradorite, whilst that in the igneous layers is microcline. The iron contained in the biotite and iron-ore of the intrusive magma has been used in the production of the pyroxene, which is presumed to be near the hedenbergitic end of the diopside-hedenbergite series.

In the banded rocks of the Mogra watercourse the reaction has usually been much less complete and we find banded rocks composed of layers of pyroxenic marble, diopsidite (with labradorite), and biotitic schist (with microcline), the diopsidite separating the invaded and intrusive rocks. The biotitic layers are also pyroxenic and the reason that the biotite has not all been destroyed is possibly that the magnesia of the dolomites is first used in the production of the pyroxene, before the magnesia and iron required for the biotite are called upon. The pyroxene is accordingly paler than in the calc-granulites and probably approximates to the diopsidic end of the diopside-hedenbergite series.

The most striking feature of the Mogra rocks is the reaction zone of scapolite between the marble and the diopsidite. Often the inter-penetration by the acid intrusive has been more intimate and then we find scapolite-granulites analogous to the calc-granulites, but frequently with some residual calcite in bands. The rocks are well banded and under the microscope show thin pyroxene-microcline streaks representing the original intrusive layers, with a band of sphene-scapolite-pyroxene-rock on each side, followed by a streak of a rhembohedral carbonate, presumably calcite. Occasionally some biotite is still left in the intrusive streaks.

On the field evidence the biotite-gneiss concerned with the formation of both the calc-granulites and of the scapolite-granulites is the same; why it should have caused scapolitisation of the dolomitic suite only is not evident. It is to be noted, however, that epidote, which is equivalent to the meionite of the scapolite with one molecule of H_2O added, is common in the calc-granulites, and is very rare or absent from the scapolitic granulites, as also is garnet,

found commonly in both the calc-granulites and the pink marbles. Blue tourmaline (indicolite) is commonly associated with the scapolite in the scapolite-granulites, and is not uncommonly found, though in smaller quantity, in the calc-granulites.

Even in the Mogra occurrences the whole of the dolomitic suite has not been scapolitised, and instead white marbles with chondrodite, green spinel, diopside, and forsterite, are not uncommon. It is noteworthy, however, that these minerals have not been serpentinised, as is commonly the case with the dolomitic suite elsewhere in this tahsil. In addition to forming bands in the marbles, the diopsidites sometimes occur in flaggy form as belts of considerable thickness.

The pegmatites of the area surveyed are also of some interest. In the Mogra synclinorium the rocks are freely penetrated by granite-pegmatite veins carrying tourmaline, biotite, garnet, and rose-quartz; the abundance of rose-quartz is such that large quantities could easily be collected.

Another pegmatite, found in the streamcourse separating Mogra from Medi, is unique, not only for this district, but for the whole province. It carries white quartz, microcline, and oligoclase with tourmaline of various tints, black, brown, green, and pink, the latter in appearance recalling the rubellite of the United States. In addition the rock carries muscovite, lilac and violet micas, and also light orange-yellow garnet. The rubellite, violet mica, and garnet, occur only in streaks in the ordinary tourmaline-pegmatite. None of the rubellite exposed at the surface was of gem quality.

In the belt of country further north near Bhedoni, Chhindewani, and Tekari (of which the two latter villages are in the Nagpur district), occupied largely by biotite-gneiss, the gneiss is penetrated by an abundance of pegmatites, also often of a curious type. They contain phenocrysts of graphic granite, or rather of felspar enclosing graphic quartz, often of large size (up to 4 feet long), and are very conspicuous. These pegmatites have been found in many other parts of the district, but have not yet been found in the Mogra belt, where the rose quartz-pegmatites prevail.

Another point mentioned by Dr. Fermor is the abundance of siliceous breccias and related epidotic rocks in the Maharkund tract in the Nagpur district in the S. E. corner of sheet $55\frac{K}{14}$. Maharkund is in the centre of a wide synclinal tract of pink calcitic marbles, with a prominent range of calc-granulites to the south. A consider-

able portion of this calc-granulite range is thought to have been completely replaced by a siliceous breccia that gives rise to the highest peaks. On the southern edge the breccia gives place to partially silicified and epidotised calc-granulites and granites, and the silicification and epidotisation are evidently two phases of the crushing by which the breccias have been formed.

According to Dr. Fermor, the southern limb of the Maharkund marble syncline, at a point opposite to the silicified section of the calc-granulites, has also suffered brecciation and silicification, in this case along a N. W. belt over a width of about 250 yards. In this silicified belt are islands of unaltered marble. Much of the siliceous rock has the aspect of a bluish grey quartzite often with parallel structures recalling bedding, as well as at times spessartite and granules of a black ore. There are patches of ground in the quartzite area occupied at the surface by rubble, which is worked locally for manganese-ore. As the latter is in nodules, often folded and contorted, exactly like those found *in situ* in the marbles in other parts of the district, the logical deduction is that the grey quartzite has been formed by the replacement of the marble, the manganese-ore nodules spessartite crystals, and black-ore granules being unreplaced constituents of the original marble.

Dr. Fox's attention was confined to an examination of the areas occupied by coal-bearing Gondwana strata, in the tract between the Kanhan river on the west and the Chhindwara-Narsinghpur road on the east, in the Chhindwara district. This necessitated a revision of the geology of the country shown on the 1-inch topographical sheets 55 $\frac{J}{11}$, $\frac{J}{12}$, $\frac{J}{15}$ and $\frac{J}{16}$ and the north-east corner of sheet $\frac{J}{7}$. The structure of the region can be briefly described as being that of a shallow syncline to the south followed northward by a corresponding anticline: both these flexures have nearly east-and-west axes. In addition to the gentle regional folding the tract is sliced by sharp east-to-west trending faults, the majority of which throw to the south and thus cause a repetition of the beds to the north. There are, however, some strong faults which throw to the north. The strata as a whole appear to dip steadily to the north in the areas where the Barakar rocks are exposed.

The Gondwana strata terminate rather abruptly against the granite and metamorphic rocks along a west-by-south to east-by-north line on the south margin of the tract under consideration.

To the east-north-east and north the successive groups of the Gondwanas are covered by the basaltic lava flows of the Deccan Trap period. Several dykes and sills of basalt and dolerite, striking east-by-north to west-by-south, are found intrusive among the Gondwana rocks of the tract examined. Underlying the basaltic lavas there are certain Infra-trappean grits of angular, granitic material, red jasper conglomerates and coarse soft sandstones, which appear to be much younger than any of the Damuda group of beds found in the south-eastern exposures of these Gondwanas. It is thought that the red jasper conglomerates at least are of Upper Gondwana age—probably identical with the sandstones, with thin zones of red jasper gravel, found in the north-east corner of the Chhindwara district. The peculiar grits north and south of Khirsadoh are the same as the grits of Gangeewara 6 miles north-west of Chhindwara town, and are probably Lametas.

The detailed mapping of the coalfields on the 1-inch maps proved somewhat difficult owing to complicated outcrops which exist, as a result of the faulting and northward dip, on a sloping ground surface. Much more information is now available from borings and mines than was available when the field was first mapped 40 years ago. Largely as a result of this new data the boundaries on Dr. Fox's map differ considerably from those shown on the old sheets.

One point of some economic value which has become evident as a result of Dr. Fox's re-survey, is that the coal-bearing strata are nearer to the surface in the strip immediately north of the Parasia branch of the Great Indian Peninsula line. This is due to the step-faulting which occurs. In two cases inliers of Talchir clays have been found in areas previously marked as Moturs. In several cases Barakar sandstones occur in the middle of strips of Motur clays, evidently due to step-faulting. None of these peculiarities were previously noted, and it is now certain that the Gondwana succession in the Satpura region will need modification, both as regards the thickness of the stages and their order of deposition. An effort in this direction was made by carrying a reconnaissance into the Denwa valley near Delakhari, but further work is still necessary to put the matter on a satisfactory footing.

Mr. W. D. West was associated with Dr. Fox for training, and under his guidance made a traverse down the Parasia branch of the Great Indian Peninsula from Parasia to south of Hirdagarh. This strip of country includes all groups of the Damuda series, several

faults and some coal mines. The revised map shows considerable differences from the old geological map constructed by Mr. A. E. Jones. Mr. West was able to agree with Dr. Fox's suggestion that the faulted inliers of Archæan crystalline rocks occurring in the Talchirs do not represent irregularities of the old land surface but are due to faulting, the Talchirs having been let down on either side.

Pench Valley; Central Provinces.

Mr. G. V. Hobson was deputed to investigate certain problems connected with the Pench Valley coalfields, and has suggested several improvements in the methods by which some of the smaller leases are exploited. Amongst other things he condemns the open-cast method of working as being short-sighted and wasteful. He also criticises the generally adopted method of opening up seams by numerous inclines, and suggests improvements in this and other directions. Samples of the working seam in a number of collieries were taken for analysis.

Chhota Udaipur; Rewa Kantha.

At the end of January Mr. Hobson proceeded to Chhota Udaipur in Rewa Kantha. The area inspected consisted largely of granite, but to the north-east there is an area of metamorphic rocks, probably an extension of the Champaner series.

Nagpur and Bhandara districts; Central Provinces.

Sub-Assistant D. Bhattacharji continued his geological survey of the Nagpur and Bhandara districts. Ten varieties of the Gneissic group were recognized and an attempt made to indicate this variation on the map; the types differentiated were vein quartz, pegmatite, granite, augen gneiss, porphyritic streaky gneiss, streaky gneiss, white acid gneiss, schistose gneiss, schist and amphibolite.

North Arcot and Salem districts; Madras.

Sheets 57 $\frac{L}{5}$, $\frac{L}{6}$, $\frac{L}{10}$, $\frac{L}{14}$, and $\frac{P}{2}$, forming part of the North Arcot and Salem districts, Madras, were partly mapped by Rao Bahadur Vinayak Rao. The oldest rocks seem to be a series of thin-banded gneisses with biotite mica which are intruded by all the other formations except the Dharwars to which they appear conformable. These gneisses are generally found in the plains and were also noticed on the southern edge of the Mysore plateau.

The Dharwars, which consist of hornblende schists, amphibolites and hæmatite quartzites with bands of limestone and chloritic schists, are developed in the N. W. part of the North Arcot district;

they extend into the Salem district where they come to an end near Maharajgad. The hornblende schists amphibolites and hæmatite quartzites are older than the rest of the Dharwars. The limestone bands which are formed mostly in the Salem district are folded along with the oldest gneisses.

Of the other granites and gneisses the hornblende granite found near Jalarpet would, according to Mr. Vinayak Rao, appear to be older than the Peninsular or Hosur gneisses, from the evidence of a chilled edge of the latter rock found in contact with the hornblende granite. There is not much difference in age between the two. A pink felspar pegmatite vein with epidote veins is found intruding all the rock formations and would appear to be the youngest of the series except the charnockites.

The charnockites were not noticed in the Mysore plateau but occur as thin bands west of Jalarpet. They are extensively developed to the east in the Javadi Hills where they form most of the prominent ridges.

The bed of the Palar which flows through the northern part of the area surveyed appears to be in a line of fault. Mylonitised and crushed zones are found both in the bed of the river and in the hills close by. There are several parallel zones showing crushing. The general trend of the hills on the Mysore plateau is N.N.W.—S.S.E. while on the Javadi Hills to the east, the hills have a N.N.E.—S.S.W. direction turning N.E. further east.

Ganjam district, Madras.

Mr. H. Crookshank, whilst examining the sands of the Ganjam coast between the Chilka lake and the Nagavali river for monazite, mapped the boundaries of the rocks occurring near the shore. His work was considerably hampered by the cyclone which in November 1923 passed over the Ganjam and Vizagapatam districts, and made roads, rivers, and the country in general impassable for a long period. The rocks which occur belong mainly to the Khondalite series and to various types of gneisses, and call for no special comment.

Vizagapatam district, Madras.

Mr. Crookshank was to have made a geological survey of the unsurveyed portions of the Vizagapatam Hill Tracts, but owing to the activities of a band of outlaws, this work had to be restricted to a re-survey of the plains of the Vizagapatam district, and of the lower hills which were considered safe. The geology of this area was very similar to that of the Ganjam coastal area.

Punjab and Poonch.

During the first part of the field season 1922-23 Dr. Pilgrim completed the geological survey of the Tertiaries of the Sutlej valley, mapping the western portion, situated in the states of Nalagarh and Bilaspur and the Kangra district, in much greater detail than had hitherto been attempted, and linking up on the east with the area round Subathu and Kasauli, which Mr. R. D. Oldham had mapped in 1889. Several cross faults and unconformities have been detected. The fossil wood horizon of Nalagarh has been recognized in several places and there is no doubt that it passes down into beds of the Dagshai stage. At the same time it is difficult in the absence of fossils to synchronize exactly the beds on the south-western with those on the north-eastern side of the well-marked ridge of Krol and Eocene rocks, since, as Dr. Pilgrim believes, the uplift of this ridge of older rock at the close of Dagshai times produced two distinct areas of sedimentation; (1) a low-lying one, in which the brackish water deposits of the Dagshai continued and (2) a more elevated one, in which the freshwater deposits, characteristic of Kasauli itself, succeeded the Dagshai. Dr. Pilgrim brought back from Kasauli some specimens of a Unionid. This, the first fossil, with the exception of plant remains, which has been found in the Kasaulis, has been provisionally determined by Dr. Baini Prashad as an *Indonaia* and it is hoped that it may afford internal evidence of the age of the Kasaulis which has so far been lacking.

Potwar plateau ; Punjab.

Mr. D. N. Wadia continued his survey of parts of the Potwar plateau in the Punjab and mapped sheets 43 $\frac{G}{3}$ and $\frac{G}{4}$ on the S. S. W. continuation of the Soan synclinal basin. This area consists mostly of Siwalik rocks, from basal Kamlials, which are described as shewing a transitional passage into the Upper Murree, to the Boulder-conglomerate zone which in turn passes up into inclined Pleistocene, recent alluvium and loess.

The Soan basin is a geosyncline, over 100 miles long and 30-40 miles broad, showing a pronounced pitch of the axis to the S. S. W. It is the relic of an older and much larger river at one time continuous with the Indus, and possibly connecting the latter with the Ganges and Brahmaputra.[1]

[1] E. H. Pascoe: *Quart. Journ. Geol. Soc.*, LXXV, p. 138 (1919).

The basal Kamlial beds exposed on the south-eastern limit of the basin have proved richly fossiliferous over a strike-length of 10 miles. They have yielded remains of two *Rhinocerotid* and three *Anthracotheroid* genera, besides *Mastodon* (or ?*Trilophodon*), *Dinotherium*, *Giraffokeryx*, three or four genera of small antelope and a molar of an anthropoid ape (?*Sivapithecus*), a large number of crocodile teeth and bones of *Trionyx* and *Emyx* with opercula of gastropods. The fossils are being examined in more detail.

Dr. Pilgrim accompanied Mr. Wadia during two entire months in the Pir Panjal, in the course of which a considerable amount of detailed mapping was accomplished. Mr. Wadia's conclusions as to the main structural and stratigraphical features of the range, arrived at as a result of the two previous seasons' work were confirmed, while certain additional important details have come to light relating to the controversial Eocene and Gondwana zones.

Pir Panjal ; Kashmir.

Dr. Pilgrim suggested a classification of the Panjal Eocene rocks, mainly on lithological grounds, into *Ranikot* and *Laki* stages—a division which seems to correspond more or less with that into Lower and Upper Nummulitic. He was also able to identify a very inconstant, but fairly widely distributed conglomerate bed as the basal bed of the Gondwana sequence. With the help of this bed the relation of the Gondwana outliers to the Metamorphic Slate series, with which they are isoclinally folded, is better understood. His discovery of a limestone containing *Productus*, resting on the Panjal Trap in the Suran valley, settles the age of the lower portion, at any rate of this limestone, which Mr. Wadia had already suspected to be Permian.

The following table gives in outline the main elements in the stratigraphy of the Panjal range, commencing from the Murree thrust-plane boundary to the Kashmir water-shed of the Range, the structure being isoclinal from one extremity to the other, with a prevalent north-easterly dip.

Murree series.

Thrust-plane.

Eocene limestones and shales of Ranikot and Laki ages in an overfolded anticline with a core of upper Carboniferous Agglomeratic slate, trap and Permo-Trias limestones.

Thrust-plane (Main Boundary Fault).

Metamorphic zone of slates, phyllites and schists with intruded acid Plutonic rocks.

Unconformity ?

Gondwana sandstones, shales and quartzites partly metamorphosed.

Conformable junction.

Panjal Agglomeratic slate and traps with basic intrusive sills and masses.

In the last general report it was stated that Mr. Wadia's identification of part of Lydekker's Kiol or Kuling beds with the Nummulitic had been questioned, owing to the fact that the very obscure and imperfect specimens assumed by him to be nummulites appeared to have closer resemblances to the Fusulinidæ. During the past field season Dr. Pilgrim and Mr. Wadia have been successful in obtaining from the beds in question undoubted examples of nummulites, so that the present writer's suspicion expressed some five years ago that the Kiol beds included Nummulitic beds has now been definitely confirmed.[1] Whether these beds include also fusuline-bearing members is a point for future research. There is now little doubt that the Uri limestone zone connects the Pir Panjal Eocene limestone belt with the well-known Mozzafarabad Nummulitic outcrop which is a continuation of the Hazara Eocene zone.

Rajputana.

During this field-season the Rajputana Party consisted of Dr. A. M. Heron, Officiating Superintendent, in charge, Mr. A. L. Coulson, and Sub-Assistant Barada Charan Gupta. The greater portion of the season was occupied in the geological survey of the Ajmer-Merwara district, which was completed, and in conjunction with this adjoining portions of the States of Marwar (Jodhpur) and Mewar (Udaipur) were also surveyed. In the south-west, the survey was joined up with that done in Marwar by Mr. H. Crookshank in 1921. The standard sheets on the one-inch scale worked on comprise the following :—141, 142, 166, 167, 198, 168, 197, 199, 200, 231 and 232.

At the beginning of the season a joint tour of the northern part of Ajmer was undertaken, partly to introduce Messrs. Coulson and Gupta to the local formations, and partly for the revision, in the light of further experience, of country covered nine years before. The Saraswati valley, and the extreme north-western boundary ridge of the Ajmer subdivision were also examined.

Dr. Heron then carried his previous season's work southwards to the termination of the Merwara subdivision, and, after visiting

[1] *Mem Geol. Surv. Ind.*, Vol. XL, pp. 439-440.

Mr. Coulson in the field, proceeded to the Nimbahera *pargana* of the Tonk State, where, however, he found that there was little to be done.

The most important portion of Dr. Heron's work was the examination of the line of unconformity which extends south-westwards from Kishengarh, and its tracing as far as the survey extended in that direction, an unbroken distance of about 130 miles. This is merely a continuation, after breaks by stretches of alluvium, of the still clearer series of exposures which has been followed in great flexures through the Alwar and Jaipur States for an even longer distance, for their connection is indicated by several exposures of conglomerate near the Sambhar Lake.

Along this line the metamorphosed sedimentaries of the Delhi System rest on the older schists, gneisses and granites of the Aravalli System often with a basement conglomerate, derived from the disintegration of the latter. The marked difference in the lithological constitution of the two systems gives rise to strikingly contrasted topography; in the Delhi area we have steep strike-ridges and narrow valleys, in the Aravallis a level "gneissic plain," with only low hummocks or pegmatite reefs breaking its monotony.

In this season's area, the immense Srinagar conglomerate, the outcrop of which is sometimes a mile wide, and which must have an actual thickness of between one and two thousand feet, extends for about 25 miles from Kishengarh, dying out towards the south-west. Further along the horizon of the unconformity, however, similar felspathic conglomerates appear, forming the great ridge near Bednor, dying out in turn and reappearing in the Mewar boundary ridge south of Deogarh, which attains a height of 3,181 feet and extends far to the south-west beyond the limits of the district. In the intervals where conglomerate is absent, a band of felspathic quartzite (metamorphosed arkose) is usually present.

The unconformable junction is not a simple one, however, for extensive thrusting and shearing have taken place along it, resulting in a great development of mylonite and crush-rocks in bands parallel to, and above and below it. The copiously granite-intruded *massif* of the older system has acted as a rigid block upon which the more stratified and adaptable Delhis have slipped and buckled in the orogenic process, and great flakes even have been riven from it. An actual thrust-fault has been mapped for about 20 miles, representing

the detachment of such a flake, while an example of an abrupt "buckle" is afforded east of Bednor, but unfortunately in this case intensive pegmatite injection has almost obscured the structure.

As was stated in last year's General Report, the rocks of the Delhi system in Merwara are preserved in two synclines folded into the underlying Aravalli system, with thrust-faulting and shearing at and near their contacts with it. They have a general N. E. to S. W. strike.

In this year's area Dr. Heron found that these two synclines gradually come together, the intervening belt of older rocks being eliminated; the south-eastern syncline, where the two meet, strikes obliquely towards the north-western, and a considerable portion of the former is cut out by thrust-faulting.

Taking a general section from east to west across the two synclines, along the latitude of Todgarh, we have :—

East.

(1) coarse, porphyritic gneisses (Aravalli system), varying from granitoid to strongly banded, forming the "gneissic plain" of central Rajputana,

(2) arkose (or conglomerate) and impure limestones at the base of the south-eastern syncline,

(3) a great width of fine-grained biotite-schists and slaty quartzites, with much pegmatite,

(4) slabby calc-schists, with much pegmatite,

(5) biotite-schists dying out towards the south-west,

(6) massive calc-gneisses, with pegmatite and aplite,

(7) biotite limestones, in part converted into calc-gneiss,

(8) slabby calc-schists with pegmatite,

(9) composite gneiss, *i.e.*, biotite schist with interfoliar pegmatite injection,

(10) band of mylonite and crush-rock along the thrust (along the strike to the north-east the central area of gneiss of the older system appears),

(11) arkose and impure limestone at the base of the north-western syncline,

(12) the "Sendra complex" of biotite- and other schists, calc-gneisses, etc., but here almost entirely replaced by intrusive epidiorite,

(13) the Nandna limestone,

(14) the Barotia group of biotite-schists, epidiorites and felspathic para-gneisses, to the north-west of which is the horizon of the Bar conglomerate, the basement of the north-western syncline,

(15) grey porphyrite gneiss of the older system.

West.

It will be seen that the successions in the two synclines are not the same, and that each is asymmetrical; this, in Dr. Heron's opinion, may in part be explained by the partial elimination of one limb of the fold as is usual in such "fold-faulted" structures, by differences of metamorphism due to the varying depths below the surface which the folds have reached and by differences in the amount and character of igneous intrusion, but there is still much which is conjectural.

The north-western syncline finally passes into the Marwar (Jodhpur) State and was mapped within that territory by Mr. H. Crookshank in 1921. The basement arkose (no. 11) attains great prominence in the Goramji hill, 3,075 feet, and then dies out to the southward, the limestone associated with it at the same time becoming very thick. The remainder of the syncline consists of the "Sendra complex" (12) and the Barotia group (14), much diminished in width of outcrop, and almost replaced by epidiorite and hornblende gneiss. The grey gneiss (15) fringes the plain along the foot of the hills. A strike valley, about a thousand feet deep, divides the high hills formed by this syncline from the plateau occupied by the south-eastern syncline, this valley probably originating in the facility of denudation afforded by the band of mylonite and crush-rock (10) developed between the two synclines.

In the latter syncline, the fine biotite-schists and interbedded quartzites (3) have been converted, over a length of about ten miles along the strike, into banded injection gneiss and vitreous quartzites, by interfoliar intrusions of pegmatite. To the north-east, along their strike continuation, these rocks are in some places free from pegmatite, in others invaded by pegmatite in large dykes and sills to such an extent that it predominates over the schists, and there is a gradual passage from this type of intrusion to that in which the pegmatite forms innumerable small layers separating the *folia.* To the south-west again this passes into the original form, with massive veins having well-defined walls, and the occurrence is an interesting demonstration of the origin of a composite gneiss.

In the south of the area examined this year the two synclines are so diminished in width of outcrop, and pegmatite and epidiorite are so abundant and all-pervading, that the tracing of the different subdivisions becomes a matter of real difficulty. For instance, at the base of the high range (3,181 feet), south of Deogarh, composed of the folded basement arkose, epidiorites obliterate the junction between the Delhi system and the underlying gneisses. These epidiorites may be post-Delhi intrusives which have taken advantage of the junction as a way of ascent, or may be metamorphosed basic effusives poured out upon the pre-Delhi land surface of gneiss, or may be pre-Delhi intrusives invading the upper portion of the gneiss.

The gneiss itself is of the usual highly biotitic type, with porphyritic pink felspar, varying in all gradations from granitoid to strongly banded, the latter being probably interfoliar injections of schists with vein material from the granitoid masses. It is in addition invaded by abundant newer pegmatite (post-Delhi), by older pegmatite (pre-Delhi), by microgranite, by epidiorite, and by dolerite plugs.

In the vicinity of Todgarh, aplite is associated with the pegmatite in the Delhi system, intimately intermixed in the same veins with indefinite mutual boundaries, and evidently introduced at the same time.

After a preliminary inspection of the Aravalli and Delhi sections to the west and east of Beawar, Mr. A. L. Coulson accompanied Dr. Heron for the purposes of instruction till the end of November. The rest of the season was spent on a survey of parts of Ajmer-Merwara (sheets 166, 167, 199, 200, 231 and 232) and the initiation of a resurvey of Bundi State.

Ajmer-Merwara sub-division; Rajputana.

Aravalli and Delhi rocks crop out in the Ajmer-Merwara subdivision and numerous intrusive rocks are associated with both systems. Alluvium covers an appreciable portion of the area but the evidence of well sections assisted in the unravelling of the geology.

The Aravallis consist of mica-schists, granulites and quartzites, profusely intruded by the so-called "older" pegmatites, gneiss and basic rocks which are variously amphibolites, epidiorite, hornblende-schists and dolerites. Where the "older" pegmatite is fine-grained and very uniform in composition, there has been the formation of migmatite (Sederholm) by intrusion of the pegmatite in veins and along the foliation planes in "*lit-par-lit*" injection.

The "older" pegmatites also intrude into and form a variety of products with the basic rocks. Where simple intrusion has taken place, the boundaries of the pegmatite are sharply defined from the basic rocks; but where assimilation and absorption have taken place, a great variety of products ensues.

The gneiss has been mapped as one rock but there are innumerable variations in texture, structure and mineralogical contents. The normal gneiss consists of quartz, felspar (microcline and plagioclase) with biotite or hornblende or both as the ferromagnesian mineral, and containing abundant sphene, magnetite and apatite with occasional zircon as accessories.

The Bhinai gneiss is the largest and the most interesting of the gneissic masses. In addition to the minerals given above, augite and garnet also occur. More than three-fourths of the periphery of this mass consists of basic rocks, and as the relations of the gneiss to these rocks are definitely intrusive, it is considered that these basic rocks have been assimilated by the intruding gneiss and the basicity of the latter is a result of the influx of basic material. The "older" pegmatites are definitely related to the gneiss and they are considered as a late product of differentiation of the gneissic magmas.

Two outcrops of Delhis were recognized in the main area, the Kailu and the Naikan-ka-khera areas. The rocks in these comprise mudstones, conglomerates, micaceous sandstones and associated igneous rocks. The conglomerate is very well developed and this, taken with the existence of a well defined fault rock, leaves little doubt that the occurrences are faulted outliers from the main Delhi series to the west of the area.

The Sawar hills form an interesting isolated area of severely folded Delhi rocks. The rock facies comprises sandstones, quartzites, mica-schists and limestones.

As intrusives into the Aravallis and also the Delhis, there are the post-Delhi "newer" pegmatites and vein-granites. The latter consist of more or less typical granites and the "newer" pegmatites, in analogy with the "older" pegmatites and the gneiss, are considered to be late differentiation products of the granite.

Dr. Heron has shewn that the Delhis unconformably overlie the Aravallis. The junction between these rock systems was followed by Mr. Coulson for some 25 miles towards Srinagar. The basal bed of the Delhis near Masuda is an arkose but this expands

northwards and changes its facies to become a conglomerate or quartzitic conglomerate. A long strip of gneiss more or less follows the junction between the Aravallis and the Delhis for a long distance.

Bundi State ; Rajputana.

The fundamental rocks of the area covered during the traverse in Bundi State were rocks which have been referred to the Aravalli system, but their facies is different from that of the rocks referred to that system in the Ajmer-Merwara subdivision. The area appears to have suffered far less metamorphism and the rock types, instead of being dominantly schistose, comprise shales, shaly sandstones, phyllites, etc., with subordinate schists; limestones also occur. With the lesser metamorphism of the area, there is almost a complete absence of gneissic intrusions. Mr. Coulson concluded that the rock types he encountered in the Ajmer-Merwara subdivision correspond to the rock types in Bundi, the latter being the less metamorphosed equivalents of the former.

Sub-Assistant B. C. Gupta spent nearly half the season in company with Dr. Heron on a revision of the geology of Ajmer and Beawar and the mapping of the Todgarh *tahsil*. After some independent work in the Jodhpur State Mr. Gupta assisted Mr. Coulson in his survey of the Ajmer *Istimrari* estates and of a small portion of Bundi State.

BIBLIOGRAPHY.

The following papers dealing with Indian geology and minerals were published during the year 1924 :—

ANNANDALE, N. . . Fossil Molluscs from the Oil-Measures of the Dawna Hills, Tenasserim. *Rec. Geol. Surv. Ind.*, LV, 97-104.

ANON . . . . . (*a*) India's Iron Ore Reserves. The Singhbhum Deposits. *Iron Coal Trades Rev.*, CVIII, 515.

(*b*) Tinplate Manufacture in India. *Ibid.*, CIX, 832-833.

(*c*) Petroleum in North-West India. *Petrol. Times*, XI, 245.

(*d*) Changes in the Indo-Gangetic Alluvial Plain. *Nature*, CXIII, 143.
(*e*) The Bauxite Resources of Kolhapur State. *Mining Journ.*, CXLV, 353.
(*f*) A Fresh Silver-Lead Discovery in Burma. *Ibid.*, CXLVI, 650.
(*g*) Jade, Amber, and Precious Stones in Burma. *Journ. Roy. Soc. Arts*, LXXII, 170.

BISWAS, S. and MAITRA, B. — On a Crystal of Monazite from Simultala. *Rec. Geol. Surv. Ind.*, LV, 333.

BROWN, B., GREGORY, W. K., and HELLMAN, M. — On three incomplete Anthropoid Jaws from the Siwaliks. India. *Amer. Mus. Novit.*, No. 130.

BROWN, J. COGGIN — (*a*) A Geographical Classification of the Mineral Deposits of Burma. *Rec. Geol. Surv. Ind.*, LVI, 65-108.
(*b*) On the Occurrence of *Ostræa gryphoides*, Schlotheim, in Calcutta. *Journ. and Proc. As. Soc. Bengal*, New Series, XIX, 75-80.

CHAPLIN, GEORGE P. — Distribution of Petroleum in Burma. *Mining Mag.*, XXX, 265-270.

COOPER, C. FORSTER — On the Skull and Dentition of *Paraceratherium bugtiense*: a Genus of Aberrant Rhinoceroses from the Lower Miocene Deposits of Dera Bugti. *Phil. Trans.*, Series B, 212, 369-394.

COSSMANN, M. — Faune pliocénique de Karikal (Inde Française) [Fin : Pélécypodes]. *Journ. Conchyliol.*, LXVIII, 85-150.

COTTER, G. DE P. — The Oil-Shales of Eastern Amherst, Burma, with a Sketch of the Geology of the Neighbourhood. *Rec. Geol. Surv. Ind.*, LV, 273-313.

DAINELLI, G. . . . Studi sul Glaciale nel Baltistan, Ladak e Cashmir. *Spedizione Italiana De Filippi nell' Himàlaia, Caracorùm e Turchestàn Cinese* (1913-14), Series II, Vol. III.

DANE, SIR RICHARD M. The Manufacture of Salt in India. *Journ. Roy. Soc. Arts,* LXXII, 402-418.

DAS-GUPTA, H. C. . On the Fossil Pectinidæ from Hathab, Bhavanagar State (Kathiawar). *Journ, and Proc. As. Soc. Bengal,* New Series. XIX, 81-86.

DUNSTAN, A. E. . . The Crude Oil of Maidan-i-Naftun. *Journ. Inst. Petr. Techn.,* X, 51-82.

FERMOR, L. L. . . Note on the Fall of Three Meteoric Irons in Rajputana on the 20th May 1921. *Rec. Geol. Surv. Ind.,* LV, 327-332.

FOSSA-MANCINI, E. . Rocce fossilifere eoceniche, o di aspetto eocenico, del Ladak (campioni raccolti dalla Spedizione Italiana nell' Asia centrale 1913-14). *Rend. R. Accad. Lincei,* Series 5, XXXIII, 1° Sem., 305-309.

GARWOOD, E. J. Himalayan Glaciation. *Geog. Journ.,* LXIII, 243-246.

GILLESPIE, JOHN The Burma Oil Company—Report on the Progress of Naphthology during 1923. *Journ. Inst. Petr. Techn.,* X, 651-653.

HALLOWES, K. A. KNIGHT The Possibility of Manufacturing Hydraulic, Puzzolanic and other Cements from the Intertrappean Volcanic-Ash and Clay-Shale of Western India. *Trans. Mining Geol. Inst. India,* XVIII, 72-75,

HARRISON, J. V. . . The Gypsum Deposits of South-Western Persia. *Econ. Geology*, XIX, 259-274.

HERON, A. M. . . The Soda-bearing Rocks of Kishengarh, Rajputana. *Rec. Geol. Surv. Ind.*, LVI, 179-197.

JAYARAM, B. . . Progress Report on work done during the Field Season of 1920-21. *Rec. Mysore Geol. Dept.*, XXI, 49-83.

JOHNSON, H. H. . . Mineral Developments in Burma. *Mining Mag.*, XXX, 209-212.

KENDALL, R. H. and HOSKING, A. F. Treatment of Gold-bearing Quartz of the Kolar Gold Field. *Bull. Inst. Mining and Metall.*, No. 242.

LOEWE, F. . . Die Eiszeit in Kaschmir, Baltistan und Ladakh. *Zeitschr. Gesell. Erdk. Berlin* 1924, 42-53.

McCARTHY-JONES, C. H. Electricity applied to the Winning of Crude Petroleum, with special Reference to the Yenangyoung Field, Burma. *Journ. Inst. Petr. Techn.*, X, 115-155.

MATLEY, C. A. . Note on an Armoured Dinosaur from the Lameta Beds of Jubbulpore. *Rec. Geol. Surv. Ind.*, LV, 105-109.

PALMER, R. W. . (*a*) An Incomplete Skull of Dinotherium, with notes on the Indian Forms. *Pal. Ind.* New Series, VII, No. 4.

(*b*) Geology of a part of the Khasi and Jaintia Hills, Assam. *Rec. Geol. Surv. Ind.*, LV, 143-168,

PARKER, J. . On Coking and By-Products Recovery Practice in India. *Coll. Guard*, CXXVII, 931-932.

PASCOE, E. H. (*a*) General Report for 1923. *Rec. Geol. Surv. Ind.*, LVI, 1-64.
(*b*) The Mineral Production of India during 1923. *Ibid.*, 109-178.
(*c*) The Bauxite Resources of Kolhapur State. *Mining Journ.*, CXLVI 551.
(*d*) The World's Petroleum Position," Presidential address, Mining and Geological Institute of India; *Transactions*, XIX, pp. 19-50.

PENMAN, DAVID (*a*) Some Problems of Indian Coal-Mining. *Trans. Inst. Mining Eng.*, LXVII, 346-352.
(*b*) Notes on the Coal-Dust Danger in Indian Mines. *Trans. Mining Geol. Inst. India*, XIX, 52-78.

POOLE, J. H. J. and JOLY, J. The Radioactivity of Basalts and other Rocks. *Phil. Mag.*, Sixth Series, XLVIII, 819-832.

PRELLER, C. DU RICHE . The Glacial Period in the Valleys of the Upper Indus and Kashmir. *Scott. Geogr. Mag.*, XL, 20-27.

RAO. B. BALAJI Report on the Work done during the Field season of the year 1920-21. *Rec. Mysore Geol. Dept.*, XXI, 131-145.

RAO, B. RAMA (*a*) Report on the Revision Survey Work of parts of Hole-Narsipur Taluk, Hassan District, 1921. *Rec. Mysore Geol. Dept.*, XXI, 146-203.
(*b*) Notes on the Work done in the Arsikere Taluk, Hassan District, and Koratagere Sub-Taluk, Tumkur District, 1921. *Ibid.*, 204-240,

RAU, L. RAMA . On the Age of the Utatur Marine Transgression. *Journ. and Proc. As. Soc. Bengal*, New Series, XIX, 87-89.

REED, F. R. COWPER Provisional List of Palæozoic and Mesozoic Fossils collected by Dr. Coggin Brown in Yun-Nan. *Rec. Geol. Surv Ind.*, LV, 314-326.

RICHARDSON, R. K. The Geology and Oil Measures of South-West Persia. *Journ. Inst. Petr. Techn.*, X, 256-296.

SEN, A. M. . . (*a*) Annual Report for the year 1922-23. *Rec. Mysore Geol. Dept.*, XXII, 1-31.
(*b*) Report on the current Prospecting Blocks in the Tumkur District. *Ibid.*, XXI, 84-130.

SINOR, K. P. . Mineral Resources of Rewa State, C. I. (Published by the Rewa Durbar.)

SPATH, L. F. . On the Blake Collection of Ammonites from Kachh, India. *Pal. Ind.* New Series, IX, No. 1.

STAMP, L. DUDLEY (*a*) Notes on the Vegetation of Burma. *Geog. Journ.*, LXIV, 231-237.
(*b*) A Preliminary Note on the Ecology of Part of the Riverine Tract of Burma. *Journ. and Proc. As. Soc. Bengal*, New Series, XIX, 91-100.

TUCKWELL, H. M. SURTEES. India's Iron and Steel Industry. *Iron Coal Trades Rev.*, CVIII, 1123-1125. (Abridged.)

VENUGOPAL, V. T. Limestone and Iron Ores in the Bhadravati-Joldhal Region. *Rec. Mysore Geol. Dept.*, XXI, 241-276.

VREDENBURG, E. . . (*a*) On some Fossil Forms of Placuna. *Rec. Geol. Surv. Ind.*, LV, 110-118.
(*b*) On the Phylogeny of some Turbinellidæ. *Ibid.*, 119-132.

WALKER, H. . . Recent Falls of Aerolites in India. *Rec. Geol. Surv. Ind.*, LV, 133-142.

WARD, F. KINGDON . The Snow Mountains of Yunnan. *Geog. Journ.*, LXIV, 222-231.

WASHINGTON, HENRY S. The Lavas of Barren Island and Narcondam. *Amer. Jour. Sci.*, Fifth Series, VII, 441-456.

WILSON, W. J. . . The Crude Oils of Burmah and Assam. *Journ. Inst. Petr. Techn.*, X, 227-255.

WOOD, W. H. A. Rivers and Man in the Indus-Ganges Alluvial Plain. *Scott. Geogr. Mag.*, XL, 1-16.

A FOSSIL TREE IN THE PANCHET SERIES OF THE LOWER GONDWANAS NEAR ASANSOL. BY ERIC J. BRADSHAW, B.A., B.A.I. (Dub.), F.G.S., *Assistant Superintendent, Geological Survey of India*; WITH A PALÆONTOLOGICAL DESCRIPTION. BY DR. B. SAHNI, *Professor of Palæo-Botany in the University of Lucknow.* (With Plate 1).

Introduction.

THOUGH fossil trees are commonly present in the coal-bearing strata of foreign countries, no large specimen had, hitherto, been found in any of the Indian coal-fields. The tree now to be described adds little to our knowledge of the exact age of the Gondwana coal-measures but the discovery is none-the-less of considerable scientific interest.

Circumstances of discovery.

In October, 1923, Mr. W. W. Whitney, East Indian Railway, Asansol, reported that fossil tree trunks had been discovered in a railway cutting about two miles from Asansol. Most of these were broken up and destroyed, but one specimen, about seven feet long, was subsequently removed to the Indian Museum in Calcutta. As widening operations proceeded in the cutting, another and larger trunk was exposed. This tree is the subject of the present paper. By the middle of June, 1924, this trunk had been exposed to a length of forty-five feet. At this stage, officers of the Geological Survey of India were deputed to supervise the removal and despatch of the tree to Calcutta.

Dimensions.

When completely exposed by trenching, the total length of the tree was some seventy-three feet. The removal of portions by the large numbers of Indians who visited the site and attributed a supernatural origin to the tree, resulted in a loss of about three feet, until a police guard was posted to prevent further pilfering. The rotted and crumbled remains of a further twenty feet could be traced *in situ*, giving an original total length of ninety-three feet, of which some seventy feet were removed to Calcutta for exhibition in the Indian Museum. The tree tapers from a diameter of 1 foot 2 inches, to 2 feet 7 inches, and bifurcates at about two-thirds of the way up from its base,

one branch being truncated, the other persisting for the rest of its length.

Site.

The tree lay in the first railway cutting between Asansol and Barachak stations of the East Indian Railway, the exact site being thirty feet to the right of the down main line, between telegraph poles 133/19 and 133/20; the base was fifty-five feet from telegraph pole 133/19, and two miles two-hundred-and-seventy-five feet west of Asansol Station. The fossil lay in a trench above the cutting, whose top is fourteen feet above formation level.

Method of removal.

The tree was in a very bad state of preservation, being brittle and badly cracked in many places. It was too long to be carried in an ordinary railway truck, and the handling of so heavy and cumbersome a specimen in the streets and Museum in Calcutta presented difficulties which made it impossible to bring it intact to Calcutta. For these reasons and with the courteous assistance of the Agent and Officers of the East Indian Railway, and in particular of Mr. H. Barron, B.A., B.A.I., Resident Engineer, Asansol, the tree was sawn into eight-foot sections by means of toothless saws and carborundum powder—a slow and tedious process which was still further delayed by the abnormally heavy rainfall and the resulting repeated flooding of the trench in which the tree lay. Each section was lapped with straw rope, and wired to railway sleepers, wooden splints being bound on where there were cracks in the trunk. The sections were then handled by gangs of Punjabi railway coolies and lifted by crane into open trucks where they were kept in place by wooden wedges, and packed in cinders to prevent damage. On arrival in Calcutta the sections were placed on motor lorries and brought to the Indian Museum.

The plate which accompanies this paper, is published by the kind permission of Mr. Agabeg, F.G.S., Asansol, and of Messrs. Johnston and Hoffmann, Calcutta, the photographers. The cutting of the sections was supervised by Sub-Assistant P. N. Mukerjee, Geological Survey of India.

Geology.

At the top of the section exposed in the cutting is the débris laid down by hand when the original cutting was dug, some twenty to thirty years ago. Beneath this bed there is about 2½ feet of arenaceous clay, with small, sorted, rounded, quartz pebbles. This is underlain by 8 feet of

sandstone which has weathered in such a way as to produce numerous, rounded, harder cores of rock, in a friable, sandy matrix. It was in this weathered sandstone that the tree was found, lying above, but not in contact with, a layer of carbonaceous clay about 1½ feet deep. The carbonaceous clay is followed by compact sandstone to an unknown depth. The rocks dip slightly south-of-east, at 5°. The tree lay east and west, and sloped, with the dip, at 5°.

The sandstone in which the fossil was found is coarse, greenish white, felspathic, and micaceous, with its felspar undecomposed. This rock forms part of the Panchet series at the top of the Lower Gondwana system. The series is of fluvatile origin, and is taken to correspond with the Bunter of Europe.

In spite of the carbonaceous nature of the underlying clay bed the tree does not appear to have grown *in situ*, but to have been buried in the silt of the flooded river which originally carried it. Neither leaves, roots, nor branches were discovered.

Palæontological Description.

The following preliminary notes are based on a few sections cut from fragments taken at random. Only the secondary wood is available, and of what there is, the preservation is extremely poor, so that anything like a complete description is at present impossible. The few anatomical details observed suffice to show that the tree belongs to the genus *Dadoxylon*. The following is a brief description.

Dadoxylon sp.

Wood compact, with narrow medullary rays and well-marked growth rings; parenchyma not distinguishable; radial walls of the tracheides provided with crowded polygonal bordered pits in alternate rows; medullary ray cells usually about three or four times as long as high, with smooth horizontal and end walls, and generally traversing two or three tracheides; pits in the field very indistinct, varying in number from one to a few.

Comparison with previously known Indian species

Two species of *Dadoxylon* have already been described from the Lower Gondwana series of India, both from rocks of Barakar age, which are said to correspond with the Permian of Europe. These species are *D. indicum*, Holden, from Deogarh, and *D. benga-*

lense, Holden, from Brahmanbarari in the Jharia coalfield.[1] This coalfield, by the way, is no longer in the province of Bengal which evidently suggested the specific name, but in Bihar.

The Asansol tree agrees with both these species in showing well-marked growth rings, and it is not unlikely that it is specifically identical with one of them. Unfortunately, a detailed comparison is out of the question till better sections are available. The chief distinctive features of *D. indicum* are (1) the transfusion tissue surrounding the pith, and (2) the island of parenchyma in each of the protoxylem groups. In the present fossil neither the pith nor the protoxylem has so far been discovered intact. In *D. bengalense* the most important character is the grouping of the bordered pits on each tracheide, the groups of adjacent tracheides not being banded radially as they are in the allied genus *Callixylon*. In the fossil before us no such grouping has been discovered, but the only spots where bordered pits are at all discernible are minute specks accidentally left in a tolerable state of preservation.

The data are therefore insufficient for definite conclusions to be drawn. There is, however, one point of minor inportance in which the fossil in question resembles *D. indicum* and differs from *D. bengalense*. This is the alternate arrangement of the bordered pits—in the few places where they are to be seen—while, in *D. bengalense*, according to Miss Holden, they are "almost invariably opposite."

As regards the general affinities of the plant, the presumption is that it belongs to the Cordaitales, one of the most important groups of Palæozoic Gymnosperms. The association, in rocks of similar age at other localities, of wood of the same type with large strap-shaped leaves characteristic of *Cordaites* (including "*Noeggerathiopsis*") seems to lend countenance to such a view. It must be recognised, however, that wood of the Cordaitean type is practically indistinguishable from that of the Coniferous family of the Araucarineæ, which have a long fossil history, probably extending back into the Palæozoic era, although the exact lower limit is unknown. There is some evidence, too, that the Cordaitales survived into the Mesozoic. But while the Cordaitales were a predominately Palæozoic group

Wider affinities.

[1] R. Holden: Two Palæozoic Stems from India. *Annals of Botany*, Vol. 31, p. 315 (1917).

there is more evidence of Araucarineæ in the Mesozoic than in the Palæozoic rocks.

If the presumption be correct that the Asansol tree is one of the Cordaitales, it may well have borne the leaves originally described as *Noeggerathiopsis hislopi*, Bunbury, a species widely distributed in rocks of Lower Gondwana age both in India and the southern hemisphere.

Climate.

The presence of well-marked rings of growth in the wood of trees is generally associated with an alternation of sharply marked seasons in the year. It may be that this characteristic has some relation to the probably severe climate due to the glaciation at the close of the Permian period, for which there is independent petrographical evidence.

PLATE.

THE FOSSIL TREE AT ASANSOL

About two-thirds of the tree are submerged in the flooded trench.

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FOSSIL TREE FROM ASANSOL.